REPORT

ON THE

EXPERIMENTAL CULTURE OF THE OPIUM POPPY

FOR THE SEASON 1877-78.

BY

JOHN SCOTT, Esq.,

Curator, Royal Botanical Garden, Calcutta; late on special duty, Opium Department.

Calcutta:

PRINTED AT THE BENGAL SECRETARIAT PRESS.

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FROM JOHN SCOTT, ESQ.,

Curator, Royal Botanical Garden, Calcutta; late on special duty, Opium Department,

TO THE OPIUM AGENT OF BEHAR.

Calcutta, the 20th November 1878.

SIR,

I HAVE the honor herewith to submit the annual report on the experimental opium cultivation in the Deegah and Meetapore Gardens for the past season.

I have the honor to be,

SIR,

Your most obedient servant,

JOHN SCOTT.

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REPORT

ON THE

EXPERIMENTAL CULTURE OF THE OPIUM POPPY

FOR THE SEASON 1877-78.

THE season 1877-78 has proved, perhaps, one of the least favourable to *opium produce* of any on record, and certainly one of the most perplexing to the opium cultivator. Much of his later-sown plant was eaten off piecemeal by grubs and caterpillars, in December and the early part of January; then, again, to his consternation, vigorous, well-developed plant yielded little or no drug, though presenting no outward symptoms of injury or disease; further indeed, than that simultaneously with the exhaustion of the milk-sap, it was infested by caterpillars of various kinds, and completely destroyed. I have specially reported on the probable cause of the plants' deficient secretion of the opium juices and the caterpillar plague. The explanations I have offered on the former, are founded on the well-known influences of weather on the phenomena of secretion and exudation of the opium juices. I have insisted, and after reconsideration of the whole subject I believe correctly, that the real source of the diminished secretion of milk-sap in this season's plant is attributable to the very marked differences in the weather characteristics of this and the preceding season (*i.e.* those of 1877-78 and 1876-77). I will briefly explain:—

2. Thus, the opium season 1876-77 was unusually moist throughout, whereas this season (1877-78), preceded by an abnormally light rainy monsoon, has been characterised by the opposite extremes of heat and drought. Having regard to the facts then, that the seed from which this season's crop was raised was grown and matured in an excessively humid season, and that the function of secretion of the opium juices is very susceptible to weather and season, it need scarcely be a matter for surprise to find the plant it gives rise to, under opposite seasonal conditions, with impaired functions—scant and impoverished secretions. It is simply an instance of functional inaptitude between the plant and the season: memorably, as disastrously, showing us the futility of attempting to raise a copious opium-yielding plant in a dry climate or season, from seed which has been grown and matured in a humid climate or season. This should always be borne in mind in the interchange of seeds of the opium poppy. The seed-produce of heavy, moist soils, for example, may be sown with advantage on similarly characterized soils in other districts; whereas it will almost to a certainty give rise to a scant opium-producing plant on a light and dry soil. The *rationale* is this—that in introducing the opium poppy from a dry to a wet soil or climate, the processes of vegetation (on which, it is important to observe, depends the function of opium secretion) are promoted, whereas in the converse case, *i.e.* from wet to dry; the reproductive functions are favoured at the expense of the vegetative. For details and illustrations of this view I would refer to my general report on the subject, submitted to the Opium Agent of Behar (No. 500, Deegah, dated the 23rd April 1878).

3. The sequel of this diminished secretion of milk-sap by the opium poppy was a raid of insect foes. In my report on these, I showed *that one and all avoided the opium poppy when the milk-sap was present,* their depredations being confined to the plant *either* in its germinal and early stages, when it is a bland and agreeable vegetable; *or* subsequently to the exhaustion of the milk-sap. After very careful and extensive observations, I have in no single instance seen either insects or other animals attack any part of the poppy plant when the normal milk-sap was present. One and all then avoid the plant, or, as I should rather say, its milky parts, for not unfrequently we find caterpillars feeding on the lower, *milk-depleted* leaves while opium is still being extracted from the capsules. I notice this as casual and, indeed, some careful, but mistaken observers will and do insist that various caterpillars feed on the parts of the opium poppy while still replete with the opium juices. This I can unhesitatingly say, is quite a mistaken and unfounded assertion. I know of no plant more effectively protected from insect and other animal foes during those stages when replete with milk-sap than the opium poppy. As in all other instances, however, the protective

principle is far from perfect, and we find it alike subject to insect and other foes during its germinal and maturing stages. For details on this and other correlated subjects I invite attention to my general report on the insect foes of the poppy and other agricultural plants (No. 504, Deegah, dated the 28th May 1878) and the preserved specimens (contained in 62 phials) of these accompanying it. I will now pass on to the general details of the experiments with my selected seed at Deegah and Metapore:—

A.—*Deegah. Enclosed Lands.*

Sowing was commenced simultaneously in both gardens on the 15th October; a fall of rain from the 5th to the 10th having prevented earlier sowing. I will first treat of that portion of the crop enclosed by the old jail walls at Deegah, under the head of the different varieties, beginning with that called *monariah-teyleah,* seeds of which have been lately distributed under the name of *Deegah-teyleah,* and is described in my annual report for 1876-77, *vide* page 12. The plot of this variety was sown on the 15th October. The seeds germinated very regularly, and gave rise to a full, healthy, and vigorous crop. The total produce of opium was 15 seers 1 chittack: the average *per beegha,* 10 seers. The total return of seed was 223 seers, of which that yielded by the selected capsules was 2 maunds 10 seers. This is a very superior variety raised in the Deegah gardens, and will I am sure be appreciated by the assamees.

2. The *broad-leaved kutila* variety was sown on the plot adjoining the preceding on the same date, and similarly treated throughout. The crop was full and regular, though upon the whole less vigorous than that adjoining (*monariah-teyleah*). It was also considerably less productive in drug, the return being 12 seers $2\frac{1}{4}$ chittacks, which was equal to 8 *seers* 1 *chittack per beegha.* The total seed produce was 138 seers, of which the selected capsules yielded 50 seers. The plant on this plot, as in the case of the preceding, was throughout unaffected by insects or parasitic fungi. Like other early crops, however, it ceased to yield drug while the capsules and other parts were green and immature. It was indeed striking as vexatious to see vigorous and healthy plants thus prematurely cease to yield drug under the most favourable conditions of weather. The cause of this I have attempted to explain in the report above noticed.

3. The next variety which I have to notice is *monariah,* which appears to be very generally grown in parts of the Patna and Monghyr sub-divisions. It has been grown on the Deegah lands for the past five years, and has been considerably improved by selection. The plot now referred to was sown on the 18th October, and bore a full and regular crop of healthy plant, yielding 18 seers of opium, which is equal to *nine seers per beegha.* The seed produce amounted to 260 seers, of which the most productive capsules afforded 118 seers.

4. The next plot which comes under notice comprised an area of four and a half beeghas. It was sown early in November with the variety known as the hill-poppy—*vide* Annual Report for 1876-77, page 12. This, unlike the preceding varieties, failed to germinate with the natural moisture of the soil, and from a scarcity in the water-supply we were unable toirrigate until near the close of November; the crop was thus very late. Early in December the then germinating plant was attacked by the grub of a cranefly. This though very minute—from six to nine lines in length—so swarmed for upwards of a fortnight as to cause very great injury to the young plant. Applications of quicklime and ashes were repeated from two to three times with no apparent advantage, and but for their early transformation into the *pupae* state they would have destroyed the whole crop. This, however, as I will now show, was all but effected by another insect foe which just then made its appearance. This was the *kumwah* of the assamees, and apparently the caterpillar form of the common European *Noctua segetum,* and which, in spite of applications of lime and ashes, infested the young plant until the end of December, and really ruined the crop. Another plot, comprising also $4\frac{1}{2}$ beeghas, was sown simultaneously with the above, and similarly treated throughout. It was also infested by the above insects, and even more seriously injured. The extent of insect injury to these crops may be judged from the opium returns, which are vexatiously low. The net return for the nine beeghas was 173 *seers,* which is equal to about 1 *seer* 3 *chittacks per beegha.*—At this period I may observe that the assamees' crops in the neighbourhood suffered similarly from these insects, and in a few instances indeed not a plant was left on the plot. The light rainy monsoon, as I have pointed out in my report on the insects injurious to our crops, was the chief cause; but besides, there were no doubt other unknown causes which specially favoured their generation and preservation. I, however, anticipate, from the weather conditions of last poppy season, that even should these insects be equally prevalent, the plant will be sufficiently rich in opium juices to protect it from their attacks, *i.e.* until the whole of the juices have been exhausted. As regards those insects which attack the poppy in its early stage, I know of no preventive or suppressive measures which can be adopted. But we have abundant evidence to show that all the early crops escaped these insects, and this cannot be too strongly impressed on the assamees.

5. I have now to notice the returns from an improved variety of *teyleah,* which occupied two beeghas of land. This plot was sown on the 19th of October, and germinated freely by the natural moisture of the soil. The plant escaped insect and other foes, and continued throughout healthy and vigorous, with the exception of a portion in the centre of the plot where the soil is radically unsuited, from some cause or other, to the poppy plant. The yield of opium was in all 11 *seers* 8 *chittacks,* which—allowing for that portion of the crop which failed, is about equal to *seven seers per beegha.* The total seed produce was 120 seers, of

which one-third was the produce of the most copious drug-yielding capsules. Of this excellent variety I have distributed in all six maunds and three seers.

6. I have next to notice a new variety raised in the Deegah gardens, and described in my opium manual (*vide* page 45). I have called it *subza kaladanthi*. It is a most copious drug-producer, and, like its parent form, the common *kaladanthi* of the assamees, yields its drug very uniformly (*i.e.* the capsules attain the drug-yielding stage almost simultaneously), which is a great saving in labour. As I have observed in previous reports, this variety is especially adapted to early cropping, and in ordinary seasons should not be sown later than the end of October. I know of none better for ridge cropping. It may thus be sown in the beginning of October if weather and soil are favourable. Late sown crops of this variety are generally scant drug-producers, the increasing heat causing the plant dry up prematurely. This, as I have elsewhere observed, is more or less the case with all these varieties which have dull green, non-glaucous capsules. The crop of the variety under notice was sown on the 17th of October. It germinated very freely under the natural moisture of the soil. It comprised an area of two beeghas, and this was very uniformly covered with healthy plants. The drug produce was 17 seers 8 chittacks, which is of course equal to 8 *seers* 12 *chittacks per beegha*. The seed produce amounted in all to 274 seers, of which 100 seers were the produce of the best drug-yielding capsules. The quantity of carefully-selected seed of this very superior early variety, distributed by me in the two agencies on my leaving Deegah, was 2 maunds 30 seers.

7. Under the name of *Deegah-monariah*, I have distributed in the agencies this season 1 maund 30 seers of carefully-selected seed, which I feel assured will give satisfaction. It is a very copious drug-producer, and alike suited for early or late cropping, though of course the early crop is invariably the more productive of drug. The area of the plot of this variety was exactly two beeghas, and was sown on the 20th of October. The natural moisture of the soil was sufficient for the germination of the seed, and the crop was uniform, healthy, and vigorous. Like all the earlier crops, it quite escaped insects and other foes, producing a very superior drug, and that, considering the season, in fair quantity. I can strongly recommend it as worthy of the attention of the officers of the agencies. In the instance of the plot under notice the quantity of opium produced was in all 18 seers 1 chittack, so that the produce *per beegha* was *nine seers and half a chittack*. Again, the total seed return was 244 seers: that of the selected capsules, comprising those with a minimum of *six* copious drug-yielding incisions, being *seventy seers*.

8. On an area of two beeghas, I sowed on the 25th of October, in about equal proportions, mixed seed of the varieties generally known as *kutila* and broad-leaved, or *chowrah-kutila*. The seeds germinated rather irregularly, and one portion only after it had been irrrigated. This portion was thus very backward, and suffered somewhat in the early stage from the cranefly grub, which first made its appearance on this plot. The plant on the other portion of the plot, as being more advanced, escaped this grub. The total produce in opium was 14 seers and 1 chittack, which is equal to about *seven seers and half a chittack per beegha*. But for the injury from insects above referred to, the produce would scarcely have been under nine seers *per beegha*. The total seed produced was 125 seers, which, as consisting of two varieties, I did not select for distribution in the agencies.

9. I have now to notice the results of a crop of a new and improved variety of the assamees' *teyleah*, distinguished by its large, roundish-oblong capsules. The plot of this variety comprised an area of one beegha, and was sown on the 18th of October. The natural moisture of the soil sufficed for the germination of the seed, and the crop was, upon the whole, full, uniform, and of course sufficiently early to escape all insect foes. This season it has been one of the most copious drug-producers, the plot under notice (one beegha in extent) yielding 10 seers $7\frac{3}{4}$ chittacks of opium. The return of seed was in all 124 seers, 60 seers of which was the produce of capsules yielding a minimum of *six* copious drug-yielding incisions. The quantity of seed of this variety made over to the Opium Agent of Behar was 1 maund 24 seers.

10. The remaining portion of the enclosed lands, comprising an area of about one and a half beeghas, was sown with mixed varieties, and yielded in all 13 seers $\frac{3}{4}$ chittacks of opium. I will now only observe that the total opium produce of the crops on the enclosed lands, estimated at a consistency of 70°, was 155 seers 8 chittacks, which, including the nine beeghas of plant destroyed by insects, is equal to about *five* seers *nine* chittacks *per beegha*, while, excluding those, the average for the remaining 19 beeghas of healthy plants is upwards of *nine seers per beegha*. Though insects have never within my experience so infested and devastated the young poppy, I have always endeavoured to have the lands under my charge sown up as early as possible; and in the present instance, but for an insufficient supply of water, the nine beeghas of plant referred to would have been sufficiently advanced to have escaped those foes.

B.—*Deegah. Open Lands.*

1. I will now review the results of the experimental cultivation of the opium plant on the land outside the Deegah jail walls. The total return in opium (at an estimated consistency of 70°), was 94 seers $7\frac{1}{2}$ chittacks, and as the area under cultivation comprises upwards of 11 beeghas, the average outturn is thus about *eight seers, three chittacks per beegha*. This was the produce of the several varieties referred to in the following cursory notice of the open land crops:—A plot sown on the 16th October with improved *teyleah* yielded in opium 6 seers $6\frac{3}{4}$ chittacks (equal to about $7\frac{1}{2}$ seers per beegha) and in seed 67 seers, of

which 39 seers were the produce of the most copious drug-producing capsules. A much higher produce would have been afforded but that a considerable portion of the plot was injured by the roots and shadow-casts of an old peepul tree.

2. On a piece of land 10 cottahs in extent I sowed on the 18th October seeds of a new and distinct mongrel variety, raised in the Deegah gardens by crossing *monariah (female)* with the Spanish poppy *(male)*. It is a plant of vigorous and robust habit, each producing from 6 to 12 or more well-developed capsules (and these, it should be observed, maturing almost simultaneously which is a good property), and affording from six to nine and even twelve copious drug-yielding incisions. I can strongly recommend this variety to the officers of the department. Seeds to the amount of 24 seers have been made over to the Opium Agent of Behar with a view to its introduction. I have given it no name, but simply sent it out as a Deegah variety. It is No. 13 of the collection placed at the disposal of the Opium Agent of Behar. The seeds of this variety in the above instance germinated under the natural moisture of the soil, and produced a fairly regular and healthy crop. I should state however, that they were far from attaining the same vigour that they acquired in the preceding season (1876-77), which was no doubt due to unfavourable weather influences, as I have above and elsewhere attempted to explain. They were also considerably less productive in drug than those of the preceding season, which, from the few plants I then had, I estimated at 15 *seers per beegha*, whereas the returns of this season's crop was only 8 *seers* 6½ *chittacks per beegha*. The opium produce of the plot under notice was 4 seers 3¼ chittacks. The drug is readily distinguishable from that of all the other local varieties, resembling more in colour, texture, and aroma the Turkey variety. The seed produce of the plot was in all 50 seers, 31 of which were yielded by capsules presenting not less than five copious opium-bearing incisions.

3. Three plots of lands, comprising an area of 29 cottahs, were sown from the 20th to the 28th of October with seeds of the *Deegah-monariah*, which, as already shown, is a very productive and desirable variety. Two of these plots required irrigation to induce the seed to germinate; the other did so under the natural soil-moisture, and was alike an earlier, a fuller, more vigorous, and productive plant. I will, however, give the results together. First, for the opium. This was in all 11 seers, which is equal to about *seven seers eight chittacks per beegha*. Again, the total produce of seed was 144 seers, 69 of which were obtained from the best capsules.

4. I devoted five different plots of land in the outer garden to the so-called, *hill-poppy*: in all an area of 2 beeghas 15 cottahs. The different plots were sown between the 18th and 28th of October, and in part germinated with the natural soil-moisture, and in part required artificial irrigation. The latter formed the later crop; but as in their case there was no want of water in the wells adjoining them, they had it when required, and the latest of the series had thus germinated by the close of the first week of November. All thus escaped injury from insects, and each plot bore a fair crop of healthy plants. The total produce of opium was 16 seers, which is equal to about 5 *seers* 15 *chittacks per beegha*; that of seed being 174 seers, of which 62 seers were collected from the best capsules. This is a very good variety of the poppy, bearing rather small, roundish-oblong capsules, which have the peculiarity of giving little or no drug on their first and second incisions (though equally firm and apparently mature as those of the other varieties, which, even on the first incisions, yield a full and plump cord), but as a rule copiously to the third, fourth, and fifth, but very exceptionally exceeding a sixth incision. The capsule is also thinner than that of any of the other varieties known to me, and of course must be incised with a light and careful hand, otherwise it is cut through and the drug lost.

5. *Teyleah*, distributed as Deegah variety No. 1.—It is distinguished from the old form by its larger-sized capsules of a roundish-oblong shape. Of this variety a plot comprising 28 cottahs was sown on the 24th of October. The soil being rather dry, it was at once irrigated after the sowing of the seed, and all germinated by the end of the first week in November. This plot was one of those which I did not ridge, the surface of the koeries being plane like the assamees' *khets*. The germinating plant failed on the flat surface of many of the koeries, while the north side of the compartment ridges was covered with healthy young plants: a familiar phenomenon in the assamees' *khet*. It is indeed a strange perversity that these assamees have sown as father and son, for generations back, in successionally recurring seasons, and do still persist in practising plane-surface cultivation in face of those practical field-lessons on the advantages of the ridge mode. The produce of the above crop was thus very considerably under that which we might have fairly anticipated from a crop of ridged plant on the same land. As it was, the weight of the drug was only 10 seers 12½ chittacks, that is, about *six seers per beegha*. The seed produce was in all 128 seers, and of this 50 seers were the produce of capsules bearing a minimum of six copious drug-yielding incisions.

6. In my Manual of Opium Culture (page 47), I have described a very distinct and productive mongrel variety, which I raised in the Deegah garden in the season 1874-75. This I have called *subza kutila* with reference to its dull green, non-glaucous capsules, and *kutila* foliage. In the season 1877-78 I had sufficient seed of this very superior variety for a plot 25 cottahs in extent. This was sown on the 25th of October, and the seeds germinated without artifical irrigation. The crop as it grew up was thin, though the plants individually were tall, healthy, and robust. The capsules were also considerably larger than those of the common *kutila*, and of an oblong-shape, giving to each incision a full and plump cord of beautiful, pinky-red drug. The crop matured, uninjured by insects or other foes, and yielded 11 seers 15 chittacks of opium, which is equal to about 7 *seers* 4 *chittacks per beegha*.

The seed produce was in all 133 seers, and of this 58 seers were taken from the most copious drug-producing capsules. I would particularly recommend this variety to the officers of the department. In closing the experimental works, with which I had been for the past six years encharged, I made over to the Opium Agent of Behar 60 seers, and to the Benares Agent 20 seers of carefully-selected seed of the above variety for distribution in the respective agencies.

7. I have now to notice the experimental results of another mongrel variety which I raised in the Deegah gardens, and noticed under the name of *monariah kaladanthi* in my Opium Manual, page 49; moreover in my Annual Report for 1876-77 (page 17) it is shown to have been a more copious opium-producer than any of the other varieties cultivated by me. The plot allotted to this variety at Deegah, comprised an area of 21 cottahs, and was sown and ridged on the 18th of October. The soil moisture was sufficient for the germination of the seed, and the north sides of the ridges bore a full and uniform crop of healthy plants. The yield of opium was 13 seers and 15 chittacks, which is equal to $13\frac{1}{4}$ *seers per beegha.* This, considering the season and the diminished productiveness of all the varieties, is a very satisfactory return. The total seed produce of the crop was 146 seers, and of this 40 *seers* were yielded by the central capsule of each plant, which had afforded a minimum of six incisions and 43 seers from the secondary and other capsules bearing not less than five copious drug-yielding incisions. I made over to the Opium Agents in all 120 seers of this excellent variety for distribution in the agencies.

8. In the outer gardens I had but one plot of the *broad-leaved kutila*, comprising an area of 10 cottahs, which was sown on the 25th of October, and required irrigation to make the seeds germinate. This they did by the end of the first week in November, and gave rise to a full and uniform crop of healthy plants. The capsules were rather smaller than usual, and yielded drug more scantily than in the preceding and previous seasons, few of them affording more than six drug-yielding incisions (indeed a majority of them only five), and so like other varieties depleted of milk-sap while still green and immature in all their parts, the opium produce of this crop was 4 seers 10 chittacks, that is, *nine seers four chittacks per beegha.* The seed produce was 62 seers, of which 28 seers were collected from the best drug-yielding capsules. This crop, I need scarcely remark, was from first to last uninjured by insects.

9. *Deegah-Teyleah.*—Of this excellent variety I sowed one plot alongside the preceding. It also comprised an area of 10 cottahs. It was sown at the same time, and in all respects similarly treated. The crop, however, was altogether taller and of a more robust habit than that of the *broad-leaved kutila.* It was also more productive, having yielded 6 seers and 10 chittacks of opium, which is equal to $13\frac{1}{4}$ seers *per beegha*, as compared with $9\frac{1}{4}$ seers for the other. The total seed produce was 81 seers, that of the most copious drug-yielding capsules being 31 seers.

10. On the remaining portion of the outer lands, comprising about two beeghas, I sowed the acclimatized Malwah and European varieties, with some few of mongrel origin between these and the local varieties. All of them were late and of low fertility, yielding, as I shall show, very little drug and seed. Moreover, though sown by the end of October, they attained the flowering stage from eight to fifteen days later than the local varieties, and were all very seriously infested by caterpillars before the maturation of the seed. Again, as regards drug, they were even at the flowering stage extremely poor; so much so, indeed, that very few of the capsules afforded three incisions, and even from these the drug-exudations were very scant: the opium returns for the two beeghas of plant being only *four seers, twelve and a quarter chittacks*—a vexatiously low degree of fertility, considering the results of preceding seasons, relatively to those of the local varieties. Then, again, the European vareties, as being much later than the mongrel kinds in attaining maturity, produced little or no seed, all being devoured by caterpillars of two or three species. These first attacked the leaves while quite green (but devoid of milk-sap), and soon reached the capsules, which they wholly devoured in many cases, shell and seeds. I was only able to save $3\frac{1}{2}$ seers of good seed from the Turkey and Spanish poppy for trial in the Botanic Gardens here. In the case of the Malwah varieties, as maturing earlier, though scarcely, if at all, richer in their drug produce, they were less seriously attacked by insects, and of course yielded more seed; but as their cultivation in the agencies has in all instances been so unsuccessful, I preserved only a small quantity for the Botanic Gardens.

11. We have now before us the net returns of opium from the Deegah gardens for the season 1877-78. These, it is satisfactory to observe, in view of the disastrous experience of the assamees generally, do not compare at all unfavourably with those of the preceding season (1876-77), even though so largely reduced also by injury from insects. Even taking the low estimate of *six seers* per beegha, I thus lost 54 seers of opium from those nine beeghas of plant destroyed by insects. This of course seriously affects the season's crop in a comparison of produce returns with that of last season (1876-77), and this more especially when, as I have shown, we have regard to the fact that the absolute fertility of the opium plant in drug was everywhere (I refer to the Government agencies) so disastrously impaired. The actual returns in opium of the two seasons' crop, at an estimated consistency of 70°, are as follow: *First*, for the season 1876-77. The opium produce of the *enclosed lands* at Deegah was 193 seers 7 chittacks, and that of the *open lands* 84 seers 5 chittacks. The opium-produce for this season (1877-78) was 155 seers and 5 chittacks for the *enclosed* crop, and 94 seers $7\frac{1}{2}$ chittacks for the *unenclosed.* Thus, if we compare the total returns of the two gardens, we find that the former season presents a maximum of only 28 seers. It should be observed, however, that the decrease is wholly due to injury caused by insects in the crop on the *enclosed lands*, whereas in the case of the crop on the *unenclosed land* the opposite holds, affording relatively

a maximum of 10 *seers.* I should explain, however, that in the season 1876-77 a portion of the outer garden land was occupied by the European varieties, and as these are very scant drug-yielders, the returns given are considerably below the normal average of the local varieties; but be this as it may, the fact that, in spite of the comparative paucity of milk-sap in this season's crop generally (owing, as I believe and have explained, to the alternation of excessively humid to a dry and hot season), the absolute loss from insects of such a large portion—nine beeghas of plant of the Deegah crop—and the really calamitous losses of the assamees in my own neighbourhood, as generally in both agencies, I think we have here a strong argument in favour of my modes of culture and selection of the seed. It has thus naturally been a great regret to me that my experimental duties in opium work should have been wholly discontinued at this stage, seeing that I might have conducted the experiments on a somewhat smaller scale, in connection with my substantive duties in this garden.

C.—*Metapore Garden.*

1. The poppy crop in this garden was one of the poorest that I have had experience of. From the sowing of the seed until the maturation of the crop there was quite an insufficient supply of water, and this though the work of deepening wells was unremittingly continued day after day to the end of the season. So low indeed was the water level even in October, that I had to have the old wells (which in preceding seasons were sufficiently deep to afford a full and regular supply of water), at once deepened for the watering of the seed-beds. This failing in the water-supply is the main cause of the poor returns which I have now to submit to you. From first to last the plant was in no part of the gardens seriously affected with insects, as was the case with the later crops of the assamees on the adjoining lands. These men had thus two evils to contend with, viz. a deficiency of water, and swarms of insect foes.—I one, a scarcity of water.

2. I will first notice the crop of the *Deegah-kaladanthi* variety on the Meetapore lands. This was one of the earliest crops, being sown on the 24th of October. It comprised $1\frac{1}{4}$ beeghas. The ridge-system of culture having been adopted, the seeds germinated in part by the soil-moisture. They were by no means regular, however, from local differences in the property of retaining moisture by the soil. I was, however, unable to irrigate the plot until about the second week of November, and even then insufficiently to effect the germination of the remaining portion of the seed. Depending thus entirely on those which had germinated by the natural moisture of the soil, my crop of this variety was thin and irregular. It, however, was none the less healthy and vigorous, nor by any means niggardly in its exudations, as we will now see. The first lancing was made on the 31st of January, and completed by the end of February. During this period, then, it afforded 15 seers of opium, which is equal to 12 *seers per beegha.* The seed produce was in all 93 seers, and of this 60 seers were yielded by the most copious drug-producing capsules.

3. A plot, comprising an area of 23 cottahs, was sown up with seeds of garden *teyleah* on the 20th of October. All was ridged, and the seeds germinated pretty freely and uniformly under the natural moisture of the soil. This plot, I should explain, lies immediately behind the Bankipore dâk bungalow, and alongside the main road. The portion adjoining the latter is much overshadowed with trees, and further injured by their roots, which extend through it to a considerable distance. At the very lowest estimate three cottahs of the plot are really unfit for poppy; the cultivable area does not thus exceed *one beegha.* The drug collections on this portion were fairly copious for the season, and in mature opium amounted to 12 *seers.* The total seed-produce was 186 seers, and of this 64 seers were yielded by capsules, presenting as a minimum five copious drug-yielding incisions. The maturing capsules were attacked by the caterpillar of the poppy-moth, *Mamestra papaveræ,* which consumed and otherwise injured a considerable percentage of the seed.

4. Under the name of *bhura-monariah* I have made over to the Behar Agent 46 seers of seeds of an excellent new variety, which originated in a plot of the *monariah kaladanti* variety, in the Metapore gardens in the season 1876-77. I observed it to be a copious drug-producer, and this season's experience confirms it. The area of the plot under it was one beegha. It was sown on the 25th of October, but failing to germinate by the natural moisture of the soil, and being unable to irrigate until the last week in November, the crop was late and very thin. The plants individually, however, were tall and robust, each bearing from four to eight well-developed capsules, and affording an average of five incisions. The produce in opium was 8 seers $4\frac{1}{2}$ chittacks; but I am certain, had the crop been at all full and uniform, the outturn would have been at least 15 seers. I would particularly recommend this variety to the departmental officers as well worth their attention. The total seed-produce was only 57 seers—by which a fair estimate of the poverty in plant may be formed, it being one of those which quite escaped caterpillar foes—of which 37 seers were yielded by the most copious drug-producing capsules.

5. The plot of the *Deegah-teyleah* comprised an area of one and a quarter beeghas. It was sown on the 20th of October, and the soil ridged immediately after. By the 30th of October the seed had begun to germinate on the cool side of the ridges. This was far from general, however, much of the soil being too dry to excite germination. This was especially the case on the eastern portion of the plot which is much overshadowed by trees. I was quite unable to get the plot, watered until late in November, and even then so ineffectively that the remaining portion of the seed failed to germinate. The crop thus consisted entirely of those which had germinated from the natural moisture of the soil. But for the ridging of the land, the crop would have been a complete failure. On the plane-surface koeries

not a seed germinated without artificial irrigation, though sown simultaneously with others on the ridge system, and under which there was sufficient moisture preserved in the soil for the germination of the seed. This is an important advantage which the ridge mode of culture has over the plane-surface plan, on that generally practised by the assamees. As regards the plot of the *Deegah-teyleah* under notice, I may here explain that though the total area of the plot was 25 cottahs, fully seven cottahs were quite void of plants, owing, as I have explained, to our being unable to get water for irrigation. The 18 cottahs which were really fairly well covered with healthy and vigorous plants gave us in all nine seers and nine chittacks of opium, that is to say, about 10 *seers* 2½ *chittachs per beegha*, which is a very fair return considering the unfavourable weather-influences which had so generally impaired the late opium crop. The quantity of seed produced was in all 96 seers only, and of this the most copious drug-producing capsules yielded 64 seers. This has, of course, been all made over to the agents for distribution in the agencies.

6. The so-called *hill poppy* had one beegha of land allotted it in the Metapore garden. It was sown on the 23rd of October, immediately ridged, and germinated pretty freely without artificial irrigation (which simply could not have been afforded it just then). I was fortunately able to irrigate it by the middle of November, the young plants having been saved by the shade afforded them on the north side of the ridges. They made rapid progress after this, and the crop proved upon the whole good. It was by no means so rich in drug as I had anticipated from the healthy appearance of the plant. Under the same conditions it is certainly a much less copious drug-producer than any of the preceding varieties, of which the results have been given from the Metapore garden experiments. Thus the plot, as I have stated, comprised an area of one beegha, while the produce in opium was only *seven seers eight chittacks.* On the capsules attaining the maturing stage, they were much infested by caterpillars, which consumed and destroyed a large percentage of the seed. This was so much the case that no selection of the capsules was made, all (49 seers) being transferred to the inferior-seed godown.

7. The *kaladanti* variety had a plot of 2¼ beeghas allotted it in the Metapore garden. As my *mallee* took far from kindly to the ridge mode of culture, and repeatedly asked me to have a plot tried on the old mode of *plane-surface* koeries, I permitted him to thus prepare this *kaladanti* plot. It was sown on the 28th of October. None of the seed germinating (unless those on the cool sides of the compartment ridges and along the water-channels) by the natural moisture of the soil, and being unable to complete the first irrigation until about the 20th of November, the crop was comparatively late. The seed, moreover, germinated very sparingly and irregularly, large empty spaces everywhere presenting themselves. Anyone could see at a glance from this to the ridged-plot crops, the advantages of the latter system, and the *mallee* even, opposed as he was in the first instance to the ridge mode, was fairly won over to it by this comparative failure of his *kaladanti* crop. The plant was, moreover, further injured by an insufficient supply of water from the germinating to the maturing stage. All were of a slender habit, rarely bearing more than one capsule, and that below the normal size. The drug-produce, as might be anticipated, was poor, and amounted in mature opium to no more than 14 seers 3 chittacks—a very poor outturn—being exactly *six seers four chittacks per beegha.* The seed-produce was in all 81 seers, from which seven seers only were taken in the selection of the capsules. The seed-produce was in this instance also largely reduced by the common ringed-parrot and caterpillars.

8. A plot of 20 cottahs (the remaining portion, *fully four cottahs*, being quite uncultivable from proximity of trees) was allotted to the garden *monariah.* This was sown and *ridged* on the 30th of October. Germination had begun on the cool side of the ridges by the 9th of November. This, however, was far from regular, and as I was unable to complete the first watering until the 26th of November, the crop was neither full nor uniform. The plants individually, however, were very healthy, bearing from three to five well-developed capsules, and these as a rule each afforded from three to five incisions, covered with a full and plump cord of drug. The collections in mature opium amounted to 11 seers 9 chittacks—a fair outturn for a rather late crop of plant in a season where the functions of secretion were everywhere more or less seriously impaired. The maturing capsule was rather seriously attacked by caterpillars, and much of the seed thus lost. Moreover, what was spared was so much injured that I had to put all (64 *seers*) in the inferior-seed godown. This and the other varieties of *monariah* are a most useful, as they are a copious drug-producing set, and well-adapted for either *late* or *early cropping*, though I again repeat that late cropping should always be avoided.

9. I now come to the last and the least productive of all the plots in the Metapore garden. This comprised an area of three beeghas, and was sown with seeds of the *broad-leaved kutila*, from the 30th of October to the 6th of November. The assamees mode of plane-surface koeries was adopted. The seeds germinated very indifferently, and not until they had been all artificially irrigated. This I was unable to complete (so scant was the supply of water in our wells, though deepening them day by day), before the 28th of November. The crop was thus late. It was also thin and irregular, koerie after koerie indeed utterly void of plants, and, moreover, the latter individually were poor and stinted. All to the last suffered from the want of water; indeed this was so serious that, during December, I had almost abandoned the crop. This I did not do, though the value of the opium and seed-produce fell far short of the expenditure on well-deepening and irrigation. It was by fully 10 days the latest crop in the Metapore or Deegah gardens, and even the largest capsules rarely afforded more than three incisions, while by far the major number were depleted of drug by a single

or twin incision. The total produce of these three beeghas was in *opium* 3 seers 12½ chittacks only, and in *seed* 24 seers. I was much disappointed with the result of this crop, as in former seasons, when there was no lack of water, the soil invariably bore a healthy and productive crop.

10. We have now before us the results of the experiments with the selected poppy seeds in the Metapore gardens, and these, I am sure, from careful and continued observations, will compare favourably with the very best of the assamees crops in the neighbourhood. I do not speak of the general average, which I can scarcely think could possibly exceed some *two* or *three seers per beegha*, as there were by no means a small proportion of the *khets* void, or nearly so, of plant. Now, it will be observed that the opium produce of the Metapore gardens was 81 seers 14 chittacks. This was the produce of 12 beeghas, the remaining portion being simply uncultivable from proximity of trees. The general average thus afforded is 6 *seers* 13 *chittacks per beegha*. This, though falling somewhat under the Deegah average, is by no means unsatisfactory, when due allowance is made for my difficulty, I should say inability, to get anything like a sufficient supply of water for the irrigation of the crop. This, of course, was one evil which I had to contend with in common with the surrounding assamees.

11. It having been thought desirable to discontinue the experimental cultivation of the opium poppy with which I had been encharged, I was directed to make over my stock of selected seed to the Agents. This I have done, the bulk having been taken by the Behar Agent. Thus, there were in all 32 maunds 19 seers, of which 27 maunds 15 seers were made over to the Behar Agent and 5 maunds 4 seers only to the Agent for Benares. To test the germinative quality of the seed I, on leaving Deegah, took samples of each variety for trial in the Botanic Gardens, and have found without exception that all were perfectly good, and germinated freely. The plan I have now adopted in preserving them is, after having the seeds perfectly dry, to sprinkle the surface with camphor, firmly stuff the mouth of the seed jar with clean cotton, cover with an earthen saucer, and lightly bind the rims of the latter and the seed jar together with a thin coating of tenacious clay. This I find more effectively preserves them, alike from seed-feeding insects and damp, than the ordinary native mode, the surface seeds being quite as good as those towards the centre of the jars. The several new and improved old varieties which I have now distributed in quantity will, I hope, meet with the attention they deserve from the officers of the department.

12. Besides the selected poppy seeds which were disposed of as above, I had in all in the seed godowns 243½ maunds of inferior seed. This, under instructions from the Board, I disposed of in the Dinapore market to the best advantage. The highest offer was Rs. 4-1 per maund for old and new seeds. This I accepted, and realized by the sale Rs. 989-3-6. Again, I had a portion of the Deegah gardens cropped with Indian-corn during the rainy season, the sale of which realized Rs. 105. The sum, *rupees ten hundred and ninety-four, annas three, and pies six*, realized by the sale of these grains, was sent to the Opium Agent of Behar with my No. 537, dated the 15th September 1878.

13. The compound achromatic microscope which I received from the Board for examination of poppy blights, &c., with various meteorological instruments, were also made over to the Behar Agent with my No. 538, dated the 15th September 1878. So also were the various agricultural implements, &c., in stock.

14. I completed my deputation services on the 21st of September, leaving the Behar stock of selected seed and the various agricultural implements in the Deegah godowns, in charge of the head *mallee*, as directed by the Behar Agent. In closing this my final report on the opium experiments which I was originally directed to undertake and conduct by the Secretary to the Government of India in the Financial Department, it will not, I hope, be deemed superfluous to here briefly re-state my views on the nature of the opium blight, and the suggestions I have made for improving the cultivation of the plant and developing, by that never-failing selective principle, its drug-secreting functions.

15. First, then, as regards blight caused by the parasitic fungus *Peronospora arborescens*. I have I believe correctly shown in my Manual of Opium Husbandry the conditions favourable and unfavourable to its development in a truly *blight form*, and the nature and extent of injury it causes in its other and more common state, as wholly dependent on the mode of development of the *mycelium* or spawn of this minute white rust. I have shown that in the spore-bearing form it is as a rule comparatively innocuous, whereas in the other mode, or with a barren *mycelium*, and thus undergoing a purely vegetative extension in the inner tissues, the destruction of the leaves is involved in the death of the *mycelium* (which is simply exhausted and dried up in the spore-bearing state), and thus, according as the weather at this stage, is wet and cold or dry and hot, the whole plant either droops and rots or simply becomes dry and shrivelled.

16. Then again, as regards improving the cultivation, I suggested some years ago the adoption of ridges as affording the shade which is so necessary to the poppy in its post-germinal stages. I have in my manual and annual reports insisted on and well illustrated the advantages of this system over the assamee's mode of plane-surface cultivation. Especially is the ridge mode adapted to early crops, as sheltering the young plants from the sun's rays and enabling them to establish themselves, when under full exposure they simply dry up and die. We have seen also in the present report its advantages under a failing or insufficient supply of water, that, for example, while seeds on ridged land germinated by the natural moisture of the soil and gave rise to a fair crop, those on the plane-surface on adjoining plots lay quite dormant until artificially irrigated. Several other advantages, which it is needless to recount here, will be found on consulting my manual and annual reports.

17. Again, I have illustrated the structure of the capsule of the opium poppy as related to the secretion of drug, and shown alike the feasibility and practicability of increasing the drug-secreting functions by raising our crops from season to season by a careful selection of the seed. This is simple enough, and moreover incurs little extra labour, consisting as it does in selecting the most copious drug-producing capsules from season to season as the seed-producers of successive crops. I have now carefully practised this in the gardens under my charge since the season 1873-74, and thus succeeded in raising very superior drug-bearing varieties. I can thus from practical experience say that in the course of a few seasons, if only conscientiously practised by the assamees, the average yield of opium per beegha throughout the agencies would be much increased. I regret that I should have thus long ineffectively insisted on the susceptibility of the opium plant to improvement by the selection of capsules for seed-produce, though there is every probability that those constantly recurring grain famines, and consequently the increasing desirability to reduce the area of opium culture for the extention of that of grain food-stuffs, may yet lead to the general adoption of the practice. This cannot be too soon. For other suggestions and explanations on the improvement of the opium poppy I can here but invite attention to my manual and annual reports, where, amongst other subjects here unnoticed, I treat on the exhaustion and renovation of the soil, the relative fertilizing properties of waters, the influence of weather and season on the opium secretions, and many other matters of practical and theoretical interest.

18. In concluding my general report, I think it desirable to append copies of my special reports to the Behar Agent (No. 500, dated the 22nd April, and No. 504, dated the 30th May 1878) on the nature and cause of the so-called blight, the prevalence of insect foes, and the nature of the injury caused thereby.

ROYAL BOTANIC GARDEN,
The 20th November 1878.

JOHN SCOTT.

E. F. M.—Regr. No. 9295—190—21-12-78.

No. 171, dated Bankipore, the 14th May 1878.

From—W. H. D'Oyly, Esq., Offg. Opium Agent of Behar,
To—The Secretary to the Board of Revenue, Lower Provinces.

With reference to your letter No. 77B, dated 15th March last, I have now the honor to forward herewith a copy of a letter, No. 500, dated the 23rd instant, from Mr. John Scott, reporting on his examination of the specimens of poppy which were sent to him from several districts in the Benares Agency, and which it was supposed had suffered from blight.

2. It will be seen that Mr. Scott failed to trace a sign of blight, or of any specific disease, in any one of the numerous specimens sent to him; but they all, in one way or another, showed that they had suffered from "unfavourable weather conditions," aggravated in some instances by late sowing and poverty of soil. Particularly, Mr. Scott thinks that the crop has been affected by the extremes in seasons of 1876-77 and 1877-78, the former of which was "excessively moist," while the latter was "abnormally dry." The plants grown in 1877-78 being raised from seed which was produced by plants which had grown in an unusually moist season, were less able to stand the abnormally dry season which followed, than they would have been had there not been so great a difference of moisture.

3. Some of the specimens he examined had stout undiscoloured stalks from 30 and 32 inches long, but the capsules were small and abortive, showing that the development of the plant was arrested in the flower-bud stage. Others were only from 6 to 16 inches long, from apex of root to capsule, leaves very small, and capsules all more or less aborted, showing that the growth was arrested at an earlier stage. In some specimens Mr. Scott found that, though the stalk was not more than from 20 to 25 inches long, they were stout and the capsules large and of normal form, but they each bore only one drug scar, and he thinks that these were abandoned as hopeless by the cultivators too soon. He has found by experience that capsules of full size and firm to light pressure yield on their first scarification a thin watery drug, but on the second and subsequent scarifications yield abundantly, so as to afford from six to ten seers per beegha.

4. In all the cases which have come under his observation, he considers that the damage has been caused by the extreme drought of the past year, following as it did a very moist season. His examination of some of the samples of soil leads him to infer that poorness of soil has aggravated the "blasting" influence of the drought. It will, however, be seen that of the soils examined, the one which absorbed moisture readily and was also fairly retentive, and which contained a fair percentage of lime, and struck Mr. Scott as being a soil of considerable agricultural capabilities, produced a crop as poor and unproductive as the crops raised on light soil which contained little or no lime and which gave off moisture very rapidly.

5. Mr. Scott recommends, first, the use in the wet and heavy soils and moister climates of seed produced by plants grown in a light and dry soil or dry climate, and insists on avoiding the converse, *i.e.*, introducing seeds from wet and heavy clay soils or humid climates, for growth on light and dry sandy soils, or drier climates. He would use in the Behar districts, south of the Ganges, seed gathered in the North-West districts, and in the unirrigated lands, north of the Ganges in Behar, he would use seed produced in the irrigated lands south of the Ganges. When *moorka* appears, he recommends, in its earlier stage of development, a liberal top dressing of *nonimuttee* and copious irrigation; but he adds that irrigation will accelerate the destruction of crops affected with *moorka* in an *advanced* stage of development. He also recommends earlier sowings and the adoption of the drill or ridge system which he has found by experiment to answer where the ordinary native system has failed.

6. Mr. Scott will report separately regarding caterpillars.

7. I would propose that printed copies of Mr. Scott's report should be supplied for distribution among the several Sub-Deputies. I am making enquiries with a view to procure some seed from the Benares Agency, for those districts in this Agency, where a sufficient quantity of seed has not been saved.

No. 500, dated Deegah, the 23rd April 1878.

From—John Scott, Esq., on Special Duty, Opium Department,
To—The Opium Agent of Behar.

In continuation of my letter No. 497 of the 5th current, I have now the honor to submit the results of my examination of the specimens of poppy, which have been communicated to me from the Sub-Agents of *Ghazipur*, *Fyzabad*, *Bareilly*, *Fatehgarh*, *Lucknow*, *Basti*, *Gorakhpur* and the Assistant Sub-Deputy Agent of Sirsa, as illustrating the form of disease which has caused more or less serious injury to the poppy crop in those districts of the Benares Agency. I append extracts from the Sub-Agents' letters accompanying the specimens, as indicating the views of those officers on the nature and origin of the affection.

2. I will first treat on the nature of the disease, and with this view will now describe the general and peculiar characteristics of the specimens sent me from each Sub-Agency. First for *Ghazipur*.—These specimens reached me in an excellent state for examination. The individual plants from apex of root to capsule varied from *eighteen* to *twenty-five inches*. all slender-stalked, with leaves, from *one* to *two inches* in length, by *half* to *one inch* in breadth; while the largest capsules are only *one* and *a half inches* by *three-fourths*, and present in a few instances only a solitary opium yielding scar. The leaves, though narrow and of a pale colour, did not even at the first look indicate any specific affection; they were simply dwarfed. With all this, however, I examined them with care, and, as anticipated, found no trace of poppy-mould, other parasitic blights, or indeed any specific disease whatever. The plants indeed (as poppy under heat and drought in the latter part of February and March always are), were infested with *thrip*—a minute insect illustrated on plate XVI of the supplement to my report for 1874. Like all other insects, however, which I have found seriously affecting the poppy, this appears only when it has been almost depleted of the opium juices, so that they do not materially affect the opium returns. I should here state, however, that I only refer now to the plant in its later stages of growth, as I am well aware that the young plant with its almost bland juices, has not a few serious insect foes. From the early prevailing heat and drought characteristic of the past season, *thrip* is likely to have been more than usually common, and though it may not have lessened the returns of drug, it no doubt will have diminished the seed returns. Thus, though abounding as it does on the plants sent me by Mr. Turnbull, I do not believe it has anything whatever to do with their poor return in drug. As to this, I am quite of Mr. Turnbull's opinion, *vide* letter in appendix, and do not regard the failure as due to any special disease or affection, but simply to late sowing and unfavourable conditions of weather.

3. *Fyzabad*.—The Sub-Agent, Mr. Gennoe, sent me a box of specimens containing good samples of the diseased plant from various parts of this sub-division. Mr. Gennoe, as will be seen by a reference to the extracts from his report, *vide* appendix B, is disposed to attribute the local failures of his poppy to an epidemic blight, and that of a *sporadic* nature, as would appear from his enquiry as to the prevailing winds in the period of its extension or development. From a careful examination of the several samples he has sent me, however, though doubtless presenting all the characteristics of a *blasted* crop, I can find no traces of *blight*, properly so-called, and as limited to injuries or superinduced disease from parasitic animal or vegetable foes. Applying, on the other hand, the term *blasted* in its ordinary form, to injuries caused by unfavourable conditions of a purely physical nature, I think it very desirable that these forms of injuries should be so distinguished, though well aware that this is by no means indicated by the roots of the terms in the old Saxon *blast* and *lihtan*. As noted in the appended extracts from the Sub-Agent's letter, eleven separate samples of plant were sent to me for inspection. Of these, Nos. 2, 2*a*, and 9 are capsule bearing plants, though only from apex of root to capsule from *six* to *sixteen inches* in height, the leaves from half an inch to two inches in length, by a quarter to three-fourths of an inch in breadth; capsules all more or less aborted, the largest only one and a half inches long, by half an inch in diameter, and all *unscarified*. The next set comprises Nos. 1, 3 to 8. These differ only from the preceding set in being somewhat taller, but poor and stinted none the less. Thus, in height, I find them varying from 12 or 30 inches, with leaves as in the preceding set, while the largest capsules measured only one and a half by one inch. A few of the capsules bear a single scarification, but appear to have yielded no drug. Very many of the capsules are quite aborted and with the stalks and leaves have assumed a purply black colour. Now, I have examined with care the whole series, and have satisfied myself that they are perfectly free from all parasitic blight forms, and the injury, as I believe is wholly due to unfavourable weather conditions, aggravated no doubt by late sowing and poverty of soil, as also, and particularly, by the extremes in the seasons hygrometrically in which the *seeds were grown* and the *crops therefrom reared*. I refer to the excessively moist poppy season of 1876-77, and the abnormally dry season of 1877-78. I can confidently state that none of the specimens sent me present any specific disease, or so-called blight, and I have reserved the whole set of specimens, in case Board may think it necessary to submit them to more experienced examiners of the diseases of plants.

4. The samples marked 10 are from the Assistants' compound at Gonda, and described "as full grown plants bearing suppressed and contorted capsules." These consist of four specimens all dry and devoid of leaves, but presenting stout undiscoloured stalks. Three of the specimens are of the common white-flowered sort with glaucous capsules, and are from 30 to 32 inches high, with capsules small and abortive, evidently from arrest in the flower-bud stage. All have poorly developed roots, and comparing the slender flower-stalks with the fairly well developed stems, it may be inferred that the arrested growth of the capsules is due to imperfect fertilization, probably caused by the storm of wind and rain alluded to in the Sub-Agent's report as having occurred about the period when these plants had attained the flower-bud stage. This would of course be aggravated by the subsequent setting in "of the dry and hot westerly winds." The most vigorous specimen of the set, however, has yet to be noticed. This has a stout well-coloured stem, 39 inches in height, and must have greatly struck the Assistant from the miserably small capsules it bore. This, however, is not at all due to disease, but simply a normal characteristic of the particular variety;

this being of one or other of the sorts figured on plate I of my illustrations with small porous capsules and seeds of a purply grey color. This the Assistant has overlooked, and thus been led to regard its relatively small and porous capsules, as due to disease.

5. *Bareilly*.—The Sub-Agent, Mr. Pratt, has sent me five bundles of affected plants from this Sub-Agency. I will notice them as indicated in the extract from his letter in the appendix marked C. The samples 1K and 3K differ only in the degree of discoloration of the capsules, which is of no importance, as simply due to the undiscoloured set having attained a maturer stage when originally affected and taken from the field. The several specimens in each bundle seem all to have been fairly vigorous, judging from the height and thickness of the culm. I can say nothing, however, of the leaves, as small portions of these only are persistent. With the exception of slight discolorations of the stems at the nobs or lines of junction with the leaf, and that of the capsules, there are no other symptoms of an unhealthy nature. The capsules, however, though well developed on most specimens, have evidently yielded very little drug, as I observe that even some of the largest capsules bear only two "patches," neither of which seems to have afforded a full cord of drug; so that, assuming these to be fair average samples, the drug produce may be estimated at from *two* to at most *three seers per beegha*. The plant, as I have remarked, being well developed this must have been very disappointing to the cultivator. Such results, as already explained, may be, and probably are, due to the extreme differences in the degree of atmospheric moisture for the seasons 1876-77 and 1877-78, this season's plant, under the prevailing drought, as the progeny of that produced under the opposite extremes, and repeated on the same soil, having failed, more or less seriously (from unexplained local differences in the soil, &c.) even as we find it to be in raising crops from unacclimated or exotic seed. Now, we know that the opium poppy, in so far at least as regards the secretion of drug, is extremely sensitive to changed conditions of growth (the results of the experiments with the Malwa poppy in Behar and Benares are familiar examples), and we thus find, as in the samples now before me, while the plant has attained its normal stature and fertility in seed, the drug-secreting function has been much impaired.

6. The bundles marked 2K differ chiefly from the preceding in having been arrested before the capsules had attained their normal size: all the parts of the plant are also more or less discoloured. These differences, however, are probably due simply to the latter plant, being some eight or ten days later than the former, both being alike void of any parasitic blight. A scarcity, or dilution of the opium juices, is also indicated in this set, by the early penetration of the capsules by the dart-moth caterpillar.

7. As regards the bundles marked 1T and 2T from pergunnah Tilhar, in the first represented by mature fairly developed and healthy coloured stalks and capsules I can see no trace of any disease, though, as in the former cases, they have evidently produced very little drug. The largest capsules, though presenting from four to five incisions, have yielded drug to two only, and that sparingly, judging from their appearance. As in the preceding set caterpillars have penetrated the capsules and devoured the seeds. The second set from Tilhar are somewhat different, a few of the plants in the bundle have stout stems, and well developed capsules, none, however, bearing more than two incisions, and there would appear to have afforded little or no drug. The remaining specimens are altogether poorer or of more slender habit with the stems and persistent bases of the leaves, more or less discoloured, the capsules arrested in the flower-bud stage, with apices curved, and approaching the flower-stalk. They, however, present no trace of any parasitic blight form, and, as in samples already described, appear to me simply *blasted*, that is, so injured by unfavourable conditions of weather on attaining the flower-stage as to arrest further growth. Heat and drought have caused the injury; and thus, with the advance of the season, and more and more unfavourable weather conditions, the later sown crop has suffered more severely.

8. In a letter, dated Camp Tilhar, the 10th instant, the Sub-Agent, Mr. Pratt, says "since despatching my first lot of specimens, I received from the Opium Agent a copy of your letter asking for some specimens in good health, out of a field in which blight had made its appearance." I have now the honor to forward specimens of such.

"The particulars I gather from the owner of the field, are that the field was sown in Kartick, the soil is *doomat*, a sandy loam; has been irrigated four times from wells, besides rain; that there were no signs of blight previous to the storm of the 16th ultimo, but subsequently it appeared. At first he did not think much of it, as it only attacked a few plants and only latterly spread to any extent. The field was manured with the ordinary refuse matters, and after the seed germinated saline earth was thrown over it. The plants in this field are generally very fine and the capsules allow of eight and nine scarifications, but this year after one, and at the most two, the juice was exhausted.

"The plants are all from one field, and the man says of the same sowing.

"After the storm on the 16th ultimo for three or four days the weather was particularly cool and pleasant, then suddenly got very warm—have these atmospheric changes any thing to do with its appearance? I, amongst others, have also noticed an unusual number of moths this year. They appeared early in March. This would account for the caterpillars being so numerous."

9. The specimens, referred to by Mr. Pratt, reached me on the 13th instant. I have examined them, and find that they may be disposed of in three sets. First, plants well

developed in all their parts, with the exception of the roots, which are short, and sparingly ramified. On opening the capsules of this set I was surprised to find that two of the eight only contained a very small quantity of perfect seed. It was quite abortive in the others, though all were perfectly free from insects. This can only have been due to imperfect development of the pollen, or that the prevailing weather conditions at the period of the flowers' expansion have been unfavourable to fertilization. The capsules, moreover, though of full size, bear each but a solitary incision, and this evidently has yielded very little drug. This, however, is very frequently the case on the first incision of the capsules, and as none of them present a second, I do think the plant has been prematurely abandoned. The perfect immunity of the capsules from caterpillars, which, according to the Sub-Agent, abounded, moreover indicates the presence of the protective opium juices.

10. The second set of specimens present fairly well-developed stems, poor and short roots, and small deformed capsules absolutely devoid of perfect seeds. Each presents on its plainer and convex surface a single scarification only, which seems to have afforded a little drug. Again, the third and last set are altogether dwarfed, have evidently attained the flower-stage prematurely, and present in all abortive capsules, some of which are denuded of their flower-leaves, others with these unopened and glued to the aborted capsule, and all parts of the plant more or less discoloured. This is the true *moorka* of the assamees, and described at page 137 of my Manual of Opium Husbandry, as also illustrated, plate XIII of my report for 1874.

11. Mr. Assistant Osborne of the Budaon division, Bareilly Sub-Agency, has also sent me specimens with information as to the soil and manures used. With reference to the blight he states, "that it was first reported early in March * * *. The appearance of the plants when first attacked was of an unhealthy yellow colour, and the stem and leaves were covered with purple spots. The capsule was soft and flabby to the touch, and on its being punctured and compressed between the fingers, a few drops of a white watery fluid exuded. There was no moisture in the stem or leaves. The next stage of the disease was the plant showing signs of withering, and in two or three days it was quite dead."

12. Mr. Osborne has sent me ten sample bundles of affected plant from different parts of his district. All are of stunted habit, and similarly affected with *moorka* at different stages of development. These are from the flower-bud stage to that of the full development of the capsule, and vary in height from 10 to 26 inches. The stems of all are slender and simple, more or less discoloured, bearing from the flower-bud sized capsules to others more or less perfectly developed, and one and a half by one inch diametrically. Some of the capsules present one and two scarifications, but these apparently have afforded little or no drug. The parts of the plants are all more or less discoloured, but perfectly free from any fungoid or insect blight.

13. Mr. Assistant Luard, of the Fatehgarh division, has sent me a large bundle of specimens from the Jalalabad district. All have a poor and stunted appearance, with slender, simple stems, terminating in small but normally shaped capsules, which have sparingly yielded opium to one and two scarifications. They, the plants, seem to be the produce of two or more different plots, as on examination I find them differing in the colour of the stem and leaves and the size of the capsules. As thus separated one series is distinguished by the more mature development a pale greyish white stem, with more or less discoloured nodes, leaves, and capsules. The latter, capsules, in many of the specimens are fairly developed, but bear only from one to two scarifications, and these evidently have afforded very little drug. The other series are from an altogether lighter, or more stunted crops. This, however, would appear to be wholly due to poverty of soil, as they are no way discoloured either in stem, leaves, or capsules, and entirely unaffected by parasitic fungi or insects. Most of the capsules bear two scarifications, but one only has afforded drug, and that, as it appears, sparingly. Poverty of soil, heat and drought, as it appears to me, have been the only injuries of this plant. *Neither set* present any new malady. There can be no doubt that we have in both but different forms of *moorka*, that is, inaptness of plant to atmospheric conditions, more or less aggravated by differences in the soil.

14. *Lucknow.*—The Sub-Agent of this division, in a letter dated the 9th instant, states that, under instructions from the Agent, he has sent me specimens of poppy plants destroyed by *caterpillars*. I received these on the 15th instant. The caterpillar injuries, however, will be treated in a subsequent report called for on the insect enemies of the poppy, and I will therefore only allude here to the general appearance of the plant, with relation to, or as having been injuriously affected by, the weather. Two sets of specimens are sent; the one comprises fairly well developed and mature plants, from 24 to 34 inches in height; the capsules are oblong from three-fourths to one inch in diameter. All, however, seem to have been alike poor drug producers, none presenting more than two incisions, and cannot in my opinion have yielded more than two seers per beegha. The seeds had been nearly all destroyed by caterpillars. The second set of specimens are from a later crop than the preceding, of slender habit, with small capsules, none exceeding three-fourths of an inch in diameter, and bear on the larger heads only a solitary incision: the drug return from such a crop could not exceed *one seer* per beegha. I may here observe that in no specimens sent me have I seen the capsules so seriously infested with caterpillars, and this apparently of a single species (judging by the few dead forms which I found in them), that figured in my report for 1874, *vide* plate XVI,

figure 3, and a number of the destructive *genus mamestra*. Many of the capsules are riddled as if with small shot; others with large strips which have been gnawed out showing that, failing in the search for seeds, of which all are void, the caterpillars had been forced to feed on the capsules. This they had been able to do at an early stage of the plant's fructification simply, as I believe, from the diluted state of the juices. They, like all others previously examined, are quite free from any parasitic blight forms. In these instances again we have clear illustrations of inaptness of plant to weather conditions impairing the drug-secreting function; so that the plant thus wanting in its protective juice has been over run with caterpillars, and that of kinds which have not hitherto been observed in the poppy, though always more or less frequent on the pulses.

15. *Basti*.—I have had a very large and instructive series of specimens from the Sub-Agent Mr. Ridsdale, accompanied in each instance with samples of the soil. The series comprise Nos. 1 to 4.

No. 1.—In the note accompanying *this* set the Sub-Agent writes: "sown in December; has received three waterings. Blight first appeared at close of February." The soil sample is in a very fine state of comminution, of an ash-grey colour, consisting largely of sand-felds-pathic and quartzose intermixed with strongly cohesive clay, and a small percentage of organic matters. Under treatment with acids it shows no trace of lime. It is light and friable, the specific gravity of samples dried at 100° Fah., being 1·515, losing water rapidly by evaporation, and must thus be but ill-suited for poppy culture in hot and dry seasons. This is well illustrated by the specimens of plant sent, which are indeed very miserable. The tallest does not exceed 13 inches in height; all bear small capsules, none exceeding half an inch in diameter, though all well filled with seeds. None present any scarifications, and may, or may not, have contained opium. Anyhow they are uninjured by insects, and also perfectly free from any parasitic blight. They have been in a word simply starved by heat and drought, the effects of weather being moreover aggravated by lightness of the soil, and the consequent rapidity with which it gives off water in dry weather.

No. 2.—The Sub-Agent's note accompanying this set states: "field sown first week of December; has received *four* waterings; in former seasons only required water two times, the soil in ordinary seasons remaining moist, as it is in the vicinity of the Sunjoo. Blight was noticed in February." This is a pale-brown coloured soil, darker when wet and also in a state of very fine division. It is a light sandy clay with a small percentage of organic matters. It contains little or no lime, gives off moisture very rapidly, the density, or specific gravity being 1·33, and thus considerably lighter than the preceding. In hot and dry seasons, such as the past, a very early crop of poppy, as it appears to me, on the drill or ridge system would have any chance of success. A December sown crop, under such unfavourable weather, and in plane koiries, I mean the ordinary mode of the assamees, could hardly be expected to succeed. It has anyhow utterly failed. The specimens sent are poor, stunted, almost leafless, the stalk bearing more or less abortive capsules, all having been arrested either prior to, or immediately after, the expansion of the flower. Of course none have yielded drug. The plant varies in height from eight to fourteen inches. All have tended to flower prematurely, and died simply of starvation in the process.

No. 3.—The Sub-Agent remarks of this set: "field sown in the *second* week of November; it has received *five* waterings. In former seasons good crops have invariably been raised in this village. The blight was first noticed about the middle of February." The bundle sent is a very large one, measuring fully three feet in circumference, and comprising several hundred specimens, all of a very uniform height, and that not exceeding *eighteen inches*. The soil is of a dull greyish-brown colour, and consists of a white quartzose sand, mixed with about 8 per cent. of a finely divided brownish-coloured clay with a fair percentage of decayed vegetable matters. Treated with acids, it gives no perceptible re-action, and thus, like the preceding, is altogether wanting in that important constituents of the finest poppy lands—*lime*. It is a heavier and denser soil than any of the preceding, its specific gravity being 2·0, and will thus be more easily manageable in hot and dry seasons. Of the very large number of specimens sent, a considerable majority have had growth arrested before attaining the flowering stage, a few only bearing capsules, but these two small for scarification. The stems and leaves are all more or less discoloured, curled, and scorched, especially the younger parts, thus presenting the true *moorka* type of affection; and this is simply, as I have elsewhere explained, the result of sun-scorching of parching plant. From a careful examination of the specimens sent, I think there can be no doubt of this, as they present no trace of any specific disease or parasitic affection and exhibit no caterpillar injury.

4. The Sub-Agent's remarks accompanying this bundle, are "field sown in the first week of December. *First* and *second* sowings having failed. Plant watered *five* times, no yield of opium. Blight was noticed first week of March. The same field sown last year with poppy; the crop was good, and plant about *four feet* in height."

16. The soil is a dull ash or slate-grey colour, consisting largely of quartzose and micaceous sand, with an intermixture of clayey loam and organic matters, all in a very fine state of division, and forming a dense plastic mud with water shrinking much and becoming very hard when dry. It absorbs moisture readily, and is also fairly retentive, with a specific gravity of 1·724. Unlike any of the preceding it contains lime and effervesces freely on being treated with acids. It is evidently a soil of considerable agricultural capabilities, even

though it has altogether failed this season to produce a crop of poppy. The specimens sent are very poor indeed. They form a large bundle—upwards of 30 inches in circumference, and though nearly all capsule-bearing, none exceed *sixteen inches* in height. The stems are very slender, the leaves short and narrow, and the capsules miniature, the largest being one by half an inch only in its diameter, but well formed and full of seeds, all having perfectly escaped the caterpillar foes. They show no symptoms of any specific disease or parasitic blight, but simply present a dwarfed and starved appearance, which is attributable to the prevailing drought-evaporation being in excess of absorption, and the normal processes of the plant impaired, it has thus flowered prematurely and died.

17. *Gorakhpur.*—The specimens sent are from the Patherwah sub-division, where the crops seem to have suffered most severely, as will be seen by a reference to the extract from the Sub-Agent's letter in the appendix. The plants all present a very stunted habit, and vary in height from 12 to 24 inches; the stems slender, and with the leaves more or less discoloured. They have been affected at stages of development, varying from the flower-bud to that of the partially mature capsule. The largest capsules, however, do not exceed half an inch in diameter, and a very few bear a solitary, and evidently scant, drug-yielding scar. It may also be observed that many of the capsules are fringed with the withered and persistent stamens, an unfailing indication of impaired vigour. Again, in the earlier affected series of specimens the capsule is arrested either before, or very shortly after, the fall of the petals or flower leaves. In the former, we find it—the capsule—dry and black, as if scorched, and not larger than a small pea; in the others the apex is more or less curved towards the base, and its parts otherwise deformed. None have yielded drug, nor do they contain any perfect seeds. I should have remarked that, though the capsules are very small in the former series, they are as a rule well-filled with good seeds, and thus bear scarcely a trace of caterpillar infection. As will be seen, by reference to the Sub-Agent's letter in the appendix, specimens have been also sent to me of plants injured by caterpillars, but these will be noticed in the subsequent report called for on the insect enemies of the past season's poppy crop. Neither of the series now under observation, however, show any trace of insect injury, nor are they affected with parasitic fungi or indeed any specific diseases, unless indeed *moorka* be so called, which, as I have elsewhere explained, is simply an arrest of growth, which may or may not result in the death of the plant (though always seriously impairing its drug-secretions), according to the more or less prolonged action of the inducing conditions and degree of adaptation of plant to the soil. In this, indeed, I but repeat the Sub-Agent's views as quoted in the appendix—"thus, in my opinion, therefore, the drying up of the poppy plant, for it appears to be nothing more, is entirely owing to the want of moisture in the soil, aggravated no doubt by the dry and scorching winds to which the plant was subject in February." These I would add have simply completed the destruction of crops previously suffering from heat and drought on light sandy soils.

18. *Sirsa*—Allahabad Sub-division.—In forwarding the specimens of affected plants from this district, the Assistant Sub-Agent observes, that "from the specimens forwarded it would perhaps appear that only backward and stunted plant was affected, but I would state that such was not the case. The disease attacked plant of all sizes and qualities alike, but owing to the lateness of the orders (the 2nd April), I have only been able to procure specimens of late plant." Mr. Assistant Paterson has sent me four bundles of plant in illustration of the prevailing disease. Three of these are very similarly affected with *moorka*, growth having been generally arrested in the flower-bud stage; and in the most advanced the capsules do not exceed half an inch in diameter, they have yielded little or no drug. The plants vary in height from 10 to 23 inches. The leaves short and narrow, and as well as the stalks more or less discoloured. All have been infested with *thrip*, an unfailing indication of failing vigour from heat and drought, aggravated and augmented moreover as would appear from the specimens sent by an impoverished soil. All are samples of a late crop, which has struggled and ultimately succumbed to unfavourable conditions of weather. They present no trace of injury from parasitic fungi or insects.

19. The fourth bundle presents altogether different features. It consists of mature and (exclusive of the capsule) really well-developed plant of normal colour. The stems are stout, and, judging from the portion sent, are of plant from two and a half to three feet in height: the leaves had all fallen. With all this strength of stem, however, the capsules, though well shaped, are very poor, varying in size from three-fourths to one and a quarter inches in length by half to three-fourths of an inch in breadth. This is a very striking feature in regarding the other parts of the plant, and considering that the normally developed capsule of the particular variety measures from one and a half to two and a quarter inches in length by one and a quarter to one and a half inches in breadth. The capsules all bear single or twin drug scars, but the majority of these show but drops of concreted drug, and have evidently been passed over by the Collector as unworthy of further labour; while the remainder, judging by the colour and cleanness of the scars, have yielded most sparingly. A beegha of such plant could not yield more than one seer of drug, and I question much if it really exceeded half a seer. Now, after a very careful examination of the plant, I can confidently say that it is perfectly free from any apparent specific disease or parasitic blight. We have a dwarfed but normally formed capsule, secreting little or no drug. This I doubt not is what Mr. Assistant Paterson refers to in his observation that the disease was not confined to backward and stunted plant, but also the early and healthy

crops. Now, in my report to the Officiating Agent, Mr. Mangles, on the diseased plants sent me from the Chupra Sub-Agent, I alluded to the sparing drug excretion from apparently healthy plant, and attributed the failing to the extremes of weather conditions in the last and the present season, an unusually dry and hot season (1876-77) having thus been succeeded by an excessively moist (1877-78). I have explained the influence of weather on opium secretion, and have insisted, I believe correctly, that seeds grown and matured in a moist climate, or even the *local produce* of a very moist season will, under heat and drought in exotic or indigenous conditions on habitat, give rise to a more or less scanty opium-producing crop. Thus would I explain the impaired productiveness of the specimens from Sirsa and elsewhere. The small size of the capsules can only be due to an insufficient supply of moisture in soil and atmosphere from the period of setting to the maturation and expansion of the flower-bud. All the plants are absolutely free from any specific disease or parasitic affection, the failing productiveness being, as I believe, wholly due to the plants in adaptation to weather and season generally.

20. *Fatehgarh.*—A case of more or less injured plants has this day, the 18th of April, reached me by parcel post, but apparently from some miscarriage I have as yet received no letter of advice or explanation of the peculiar forms of disease they are intended to represent, or rather, as I should say, presented in the fresh state in the field all being perfectly mature, dry, and leafless. In the absence of other information then, I will simply treat of the general habit of the plant, and any disease or injury of which it now presents evidence. In all five bundles have been sent, two of which present insect injuries (and will thus be treated in my subsequent report), two other sets having all the appearance of healthy and vigorous plant, have evidently yielded little or no drug, while the last presents more or less dwarfed and deformed capsules, with stout, well developed stalks. The first two sets differ only in the colour of the capsules, one having quite the normal mature colour; while the other is more or less discoloured from the imperfect expansion and adhesion of the flower-leaves or petals. They may thus be treated conjointly. The plants, though not tall, from 20 to 25 inches only, have rather stout stems and capsules from one and a half to two inches in length, by one to one and a half in breadth, and of which those that I cut were well filled with good seeds. For reasons best known, however, to the cultivator of the plants sent, none of the capsules, all large and of normal form, bear more than *one drug scar*. Now, this in each case appears to have yielded such a small quantity of drug that the cultivator apparently has not thought it worth the labour of collection, and apparently without further experiment has simply abandoned the crop. This was a mistake. I have frequently observed capsules of full size, and firm to light pressure, yield on their first scarification a thin watery drug (and that so sparingly that the concreted matters scarcely paid the labour of collection), nevertheless, so increase in the second and subsequent scarifications, as ultimately to afford from six to ten seers per beegha. I could illustrate this from certain varieties in the gardens under my charge, and this even during the season now closed. As I have in another similar case previously observed then, I do think that the crop has been overhastily abandoned. This opinion, I need scarcely remark, is of course wholly founded on the few specimens sent me for examination. They present no symptoms of any specific disease. The third set of specimens differs from the above, in presenting with stout and well developed stalks, dwarfed and more or less deformed capsules containing few good seeds. Of this lot there are but four plants, none have borne more than one capsule, and each exhibits a solitary and unproductive drug scar. In this case the dwarfed and stunted appearance of the capsule indicates clearly enough that any further scarification would be but labour lost. The plants have been affected with *moorka* in the flower-bud stage, which has early effected the arrest of the capsule, all of which are small, misshapen, and discoloured; the stems are but slightly so, and this chiefly at the nodes or bases of the leaves. They bear no trace of injuries from insects or parasitic fungi; but have clearly enough been destroyed by *moorka*, an affection everywhere, as it would appear, more or less prevalent, and in one form or other, as modified by soil, locality, and weather, proving the real bane of the past season's crop.

21. I cannot say whether *moorka* has been more prevalent in the Benares than in the Behar Agency; though it is not improbable that it may have been, when we consider that heat and drought induce and so favour its development, as to give it quite an epidemic character. The only specimens sent me for examination and report by the Behar Agent came from Chupra, where *moorka* appears to have been prevalent, as I know (from personal observation) it has also been in this district aggravated, however, as in many cases it was, by poverty of soil. The plant never assumed the true *moorka* symptoms, but prematurely attaining the flowering stage, simply withered and died. Even early in February I observed plant from six to eight inches in height only thus being destroyed. In the gardens under my charge the later sown crops alone suffered. These comprise those sown about the end of October, but which I was unable from the failing supply of water to irrigate before the middle of November. Much of this plant was affected with *moorka* about the close of February, but its most serious injuries were two species of caterpillars which attacked it in the germinating stage, and really destroyed it piece-meal. I only casually allude to these here, however, as I will have occasion to notice in detail their characters and extent of injury in a subsequent report on the insect enemies of the plant.

22. Having now described the peculiar features of the affected plant from the various districts from which specimens have been communicated, I will now more particularly treat of the origin or cause of injury, and indicate such measures of a preventive, remedial, or mitigative nature, which occur to me as practicable. With this view I would first observe that the specimens of affected or injured plants sent me present two characteristic or peculiar forms. I thus distinguish them, premising, however, that as it appears to me, they have a common origin. The one form, though not really peculiar to, has certainly been most strikingly developed in the earlier sown crops, though in all I believe it has more or less diminished the drug returns, and thus forcibly illustrates the influence of weather in the secretion of the opium juices, as I have elsewhere insisted. Now, in this form we have vigorous well-developed plant, acquiring when mature the strawy yellow colour so peculiarly characteristic of that unaffected by any specific disease, parasitic fungi, or insects. The roots, the stems, the leaves, and the various parts of the flower, are all normally developed, and we have the capsule, moreover, well-filled with good seed; yet with all this, we find that the secretion of drug has been seriously impaired. Early in the season, these results perplexed me much, and long after I had satisfied myself as to their cause, I have heard the assamees in the district expressing their surprise at *green, vigorous*, and evidently *healthy* plant with large capsules yielding drug, and that even sparingly to *two* and *three scarifications only*. Simultaneously with this, they having observed the plant more or less infested with caterpillars of various kinds. As not having been seen hitherto to attack the poppy so numerously and early in the season, they very naturally attributed this premature exhaustion of the opium juices to the caterpillar infection. This of course was a mistake. No caterpillars, in so far as my observations go, will attack the opium poppy when replete, or at all strongly tinctured with its normal secretions. However, this is foreign to the subject of my present report, which has simply to do with such specific diseases, blights, or injuries of a purely physical character that may have affected the plant, in so far as regards the normal development of its parts and those protective secretions which give it such a high place in the *Materia Medica*. In a report dated the 1st March 1878 (to the Officiating Opium Agent of Behar), on a parcel of diseased plants communicated from the Chupra district, I submitted explanations on the nature and origin of the above and other injuries which the poppy plant had sustained during the past season. I also treated on the increased number of the plants' insect-foes during the past season, and explained the probable cause of this greater liability to such pests. Now, as I have seen no reason to change my views on any of the above questions, I will here but briefly re-state those relating to the cause of the impoverished drug-returns of apparently healthy plant.

23. The cause of this phenomenon, as it appears to me, is very simple, and wholly attributable to the extreme differences of weather prevailing in the late (1877-78) and the previous season (1876-77) as also their preceding monsoons. Thus, in 1876-77, with a full average fall of rain during the monsoon, we had from September to March, inclusive, in all 11·92 inches (a high *maximum* average), and this moreover increased by the high degree of atmospheric humidity, prevailing between the intervals of fall in rain, which, I need scarcely remark, more than the absolute fall in rain affects vegetation. Under highly electric atmospheric conditions we may indeed have heavy rainfalls of little utility to vegetation as being again rapidly evaporated by our dry westerly winds. The hygrometer, rather than the pluviameter or rain-gauge, indicates the true bearings or relations of the plant and the atmosphere in any particular season. The late and previous poppy seasons have in this respect been especially characterised by the opposite extremes of *dryness* and *humidity*, and this, as I believe, to the prejudice of our late opium crop.

24. Passing then from the poppy season 1876-77 to that of 1877-78, which, preceded by abnormally low monsoon rains, presented also a relative deficiency of 3·69 inches rain, in the seven months ending March 1878, this being moreover aggravated by the comparatively high average differences between the dry and wet bulb thermometers. The hygrometric conditions of the two seasons have thus been strongly marked, and this, as I have already remarked (and will now explain), to the prejudice of the plant now harvested. Reflecting, then, on the high degree of atmospheric humidity which prevailed in the opium season 1876-77, during which the seed for the late season's crop was grown and matured, I do think that there has been in all cases a more or less pronounced functional inaptitude between the plant it produced and the season which has been characterised by a low degree of humidity and early or unseasonable increase of temperature. I have in previous reports to the Board given reasons for the view I suggested, as to the opium secretions being purely a function of the vegetative system, and in no way dependent on the processes of fertilization or reproduction. I have in fact shown, that unfertilized capsules produced quite as much drug as those which had been fertilized. Keeping this in view, then, and remembering that the opium juices are not assimilated by or in any direct way contribute to the growth of the plant, it is easy to see that they are much more likely to be affected by seasonal variations than the parts in which their peculiar system is incorporated. Having regard then to the late and preceding seasons, I do think, as observed in my report on the Chupra plants, that the later seed-crop developed and matured under a high average; indeed a maximum humidity was really unsuited for *local cultivation*, that is, on the same soils this season characterised as it has been by extremes of heat and drought. Thus

quoting from the report above referred to, I have remarked that, "comparing this opium season and the preceding, we have in fact raised our crop from seeds equally unsuited to climatal, or rather, I should say, seasonal, conditions, as if we had introduced them in normal average seasons from Lower Bengal or even the Malayan Peninsula. As illustrating this view we have the disastrous results of experiments in Behar and Benares with seeds from the equally humid climate of Malwa which, as I think more than even the innate apathy of the assamees, has utterly discouraged experiment, and thus frustrated my work, that is, in adopting and applying the system of selection to the opium poppy which has never failed in either kingdom of organic nature to develop and confirm any particular character, be it morphological, physiological, or I may even add biological. I do not doubt, however, this principle of selection, ignored though it almost is as applied by me to the poppy, will be ultimately adopted by the assamees generally. Indeed, I am sure that there are not a few of them in this district now who begin to appreciate its advantages.

25. I am thus of opinion that the above noted extremes (in weather and season) from cool and humid to heat and drought have been the main cause of the deterioration of the late season's crop. I venture to state that, under the converse conditions of weather and season (that is, a dry season succeeded by a humid), the plant would not have been so deteriorated. The *rationale* of this view is that in introducing poppy from a dry to a wet climate the processes of vegetation, and consequently drug secretion, are promoted, whereas in the converse case, *i.e.*, from wet to dry, the reproductive functions are, on the other hand, favoured at the expense of the vegetation, of which, as I have pointed out, the secretion of the opium juices is a peculiar function. Our late crop has thus been impaired, as being the produce of seed developed and matured in a very moist season.

26. Of course, for crops thus affected no measures of a remedial nature are practicable, but something, as I think, may be done in future to mitigate at least, if not altogether prevent. With this view I would suggest the local transfer of seed from *drier* to *more humid districts*, especially on the recurrence of such an excessively moist season as that of 1876-77, and this in case as frequently happens of its being succeeded by the other extremes of heat and drought. The introduction of seed, moreover, in all seasons from *drier* to *wetter* localities, or even in any given locality from a *light*, *dry*, and *sandy soil*, to the heavier, moister, and more retentive clays, might be advantageously practised. This, I am convinced, is well worth the attention of the officers of the department. Then, as illustrating a system of local introductions, I would have the seed produce of the irrigated lands on the south of the Ganges largely used in the unirrigated lands to the north. Again, generally for the south Gangetic districts of the Behar Agency, it would doubtless be a benefit to have seed from the drier districts of the North-West Provinces or the Punjab. In all cases, the principle to be observed in my opinion is to transfer seeds grown on a light and dry soil or dry climate to wet and heavy soils or moister climates always carefully avoiding the converse, *i.e.*, introducing seeds from wet and heavy clay soils or humid climates for growth on light and dry sandy soils or drier climates.

27. The other form of disease or injury which the various district bundles of specimens present is the so-called *moorka* of the assamees, an affection, as I have explained, induced by heat and drought, and variously modified by local conditions of soil, &c. As might be expected, the later sown crops have been the more seriously affected; indeed, the advanced or early plant almost entirely escaped, the exceptions being chiefly attributable to a dry, hot, and impoverished soil.

28. Little can be done of a remedial nature for crops on which *moorka* is at all general and severe. In its *earlier* stages of development a liberal top-dressing of *nonimuttee* and copious irrigation will generally arrest it, and the affected plant even after the apical bud is destroyed will give off lateral capsule-bearing shoots. These, however, rarely acquire their normal vigour, and the capsules afford but scanty drug excretions. Again, irrigation of crops *seriously affected* with *moorka* in an advanced stage of development will simply accelerate their destruction. This has been the case in these districts (as observed by the Sub-Agents in their reports) in which after a heavy fall of rain the disease was aggravated, the application of water, when the plant is seriously affected with *moorka*, causing a rapid and deep discoloration of its parts, and subsequent death. On the other hand, if water is withheld, the plant will simply wither and die, with little or no discoloration of its parts. *Moorka*, or sun-scorching, thus presents a variety of symptoms, according as the affected plants may have been exposed to more or less moisture in the atmosphere and the soil.

29. The prevalence of *moorka* on the poppy plant in the late season is no doubt largely due to the same causes which have impaired the secretion of drug in the healthy and normally developed plant, that is, consecutive *wet* and *dry seasons* aggravated by temperature. I would also point out that these deteriorating seasonal influences have doubtless in many cases been further aggravated by indiscriminate interchange of seed, and consequently the use of that grown and matured on heavy clay soils on those of a light or sandy character. The assamees' attention should, I think, be drawn to the deteriorating effects of such interchanging of crop-seeds in such consecutive seasons as the past especially. They have no idea how seriously it deteriorates the opium crop.

30. Again, it is particularly remarked by a few of the Sub-Agents that the earlier sowings in many instances failed from heat and drought. It should be observed, however,

that these sowings were only made from the end of October to about the middle of November. In the gardens here I commenced sowing on the 15th of October, and by adopting the drill or ridge system (which I have so frequently recommended) the seeds germinated freely on the cool (*the north*) side of the ridge, and produced a full and uniform crop. On the other hand, even later sowings in koeries on the plane surface as practised by the assamees failed almost wholly, though I was at the trouble of watering immediately after sowing the seed and subsequently breaking up and pulverising the soil to facilitate germination. The advantages of the ridge system, and this especially for early cropping, will, I am sure, be generally admitted when fairly tried, as it has been in many instances, in spite of the assamees' prejudices. In this view of the advantages of ridge culture I have at least the unqualified support of two of the Sub-Agents Messrs. Peppe and Gennoe, and also the highly satisfactory results of Mr. Philips, who conducted in part the experiments with selected seed in the season 1876-77 for the latter officer. With reference to the suppression, or at least mitigation of *moorka* on the poppy I will only add that, as it appears to me, the only practicable measures are *early sowing, drill,* or *ridge culture,* and the introduction of seeds from *lighter* to *heavier and more retentive soils.*

31. In conclusion, I will only add that I have been much struck with the freedom of the many specimens sent me (from nearly all the sub-divisions of the Benares Agency) from the common poppy-mould, *Peronospora arborescens.* This has been the case also with the plant in the gardens here, as also that which has come under my observation in this district. I think this, with the prevalence and increased variety of caterpillar forms, which have preyed on the poppy during the late season, can only be explained by the dilution or alteration of the plants' juices, and of this we have unfortunately sufficient evidence in the scanty drug exudations, even from the earlier, well-developed, and apparently healthy plant. Blight, properly so-called, and as caused by parasitic fungi, I repeat, has really had nothing whatever to do with the failing of the many parcels of plant sent to me for examination, nor has it in any serious way affected crops within the range of personal observations.

APPENDIX.

Extracts from Sub-Agents' Reports.

A.—The Sub-Deputy Opium Agent of Ghazipur, with reference to enquiries of mine, whether it would now be of any practical avail visiting the division to examine and report on the nature of the blight which affected the plant, observes "that as all the plant has long been uprooted, no advantage would be gained by your visiting any portion of my division.

2. "As suggested by you, I am forwarding samples of plant affected by the so-called blight, for microscopic examination. As you invite my opinion regarding the nature, &c., of the so-called blight, I beg to state that it is evident from the appearance of the plant, that the blight was not produced by any inbred disease, nor by parasitic fungi, but solely by premature decay acting on plants already enfeebled by abnormal conditions of soil and weather.

3. "The late drought, as you are aware, interfered greatly with the proper tillage of the land, and the absence of the requisite quantity of moisture in the soil at the most critical period in the existence of the plant, viz. when about to mature, proved fatal to it. The plant that was affected was entirely raised from seed sown late in December, and, as far as I could judge, was confined to soil of a loose sandy nature. Thus it is not surprising that the later sown crop, raised under the disadvantages noticed above, should have succumbed so rapidly to the scorching westerly wind which prevailed during the first week in March."

A. H. Turnbull.

B.—The Sub-Deputy Opium Agent of Fyzabad, with reference to my enquiries, observes that "I have at present, as furnished by Mr. Carter, the following specimens of the affected plants—

No. 1, samples of blighted plants in different stages of the disease from Naubasta village.

No. 1*a*, samples of capsules which have received four incisions, from Golabsing Lumberdar's field, at Naubasta.

No. 2, samples of diseased plants, from Shewden Assamee's field (of 10 biswas) at Rancherapore.

No. 2*a*, samples of affected plants from two or three other fields at Ramcherapore.

No. 3, samples of blight-stricken plants from different fields at Mojhowra.

No. 4, samples of plants from Ramsarun Assamee's fields (of 1 beegha 15 biswas) at Russipore.

No. 5, samples of completely and partially affected plants from Ramjianun Lumberdar's hree fields at Raipore.

No. 6, samples of plants from some of the fields at Naipore.

No. 7, samples of plants from some of the fields at Hazeetpore.

No. 8, samples of plants from some of the fields at Chandapore.

No. 9, samples of plants from some of the fields at Bhugahur.

No. 10, samples of full grown plants, bearing suppressed and contorted capsules, from fields in assistant's compound at Gonda.

No. 10*a*, samples of largest and most numerously tapped capsules from fields in assistant's compound at Gonda.

No. 11, samples of capsules attacked by caterpillars from different villages. I find that what you require are plants in the least advanced state of the disease. I have asked Mr. Carter to procure these, and both sets of the specimens can be sent together for your inspection; but I very much fear at this advanced period of the season the plants must have been cut down, and the lands prepared for the reception of the coarse food-grains usually at this time of the year.

2. I have already submitted in original to the Agent a long and carefully drawn up report by Mr. Carter; and I have asked a copy thereof might be supplied to you. The following is a brief skeleton sketch of Mr. Carter's report.

Blight was most severe in the south-western portion of pergunnah Nehadewa, zillah Gonda. It showed itself about the middle of February after the storm of wind and rain we had on the 11th of that month. The crops which had been on the whole good began to have an unhealthy appearance. In course of time the plants budded and flowered and even bore capsules, but of some the buds never opened before the plant died. In some plants, after the evolution and fall of the sepals and petals, the stamens remained persistent, forming a shrivelled fringe around the base of the capsule. The appearance presented by some of the capsules was miserable, with one or two black spots on each of them; of others the capsules were deformed with a resinous matter exuding from the deformed part, the yield in both instances being scanty. Some of the capsules were stunted, with the upper portion of leaves slightly tainted, revolute, and representing a black lump at the top. It is noteworthy that in some cases the plant was attacked after the produce had been collected. The colour of the plants was of a pale yellow green, afterwards changing into a purply black. The disease which had at first appeared in solitary cases rapidly developed into an epidemic, the cultivation in the low lying sandy tracts suffering most. It is noteworthy that irrigation had the effect of spreading the disease with greater virulence, and in several of the fields Mr. Carter noticed that caterpillars had attacked the plants. The disease has never been known in the district before.

3. The disease was most destructive in the Gorakhpur district, and I have requested Mr. Carter to find out the direction of the wind current during the time the disease prevailed, as it may be interesting to discover whether the disease was imported into Gonda from Gorakhpur.

4. If the disease be proved to be local, I think we are fortunate that its effects have been no worse, considering the impoverished nature of the ground, from want of moisture on account of drought, where some of the sowings had to struggle to growth after failure."

T. GENNOE.

C.—The Sub-Deputy Opium Agent of Bareilly, advising despatch of five specimens of poppy plants from the Shahjehanpore Kotee of the Bareilly division, states that "the ones marked 1K, 2K, and 3K are from pergunnah Kout which lies close to the Fatehgarh district, where I hear blight has been bad, and also to the pergunnahs of the Bodaun sub-division from where my Assistant Mr. Osborne reports that blight has caused a great deal of injury (I have instructed this officer to send you specimens). 1K is bad, and 2K is less, but capsules injured by caterpillars eating into them; 3K has also been attacked by caterpillars, but appears to have been neglected and allowed to dry up as no signs of disease have shown themselves.

The other specimens are from pergunnah Tilhar; 1T shows slight blight, but the greater injury is from caterpillars, and No. 2T has dried up.

The blight is said only to occur in the later sowings.

I have not been over the ground myself, so cannot give much explanation, but shall be happy to make any enquiries that you may suggest."

H. J. PRATT.

D.—The Sub-Deputy Opium Agent of Basti, in advising me of the despatch of affected plant and soil samples, observes, "I am glad to state that the malady is not general or throughout my division, but is confined principally to the southern portion forming the boundary of the above three kotees, a stretch of land of about 52 miles in length and bordering the river Gogra.

2. The sowings this season were rather late, as the weather at the commencement of November was much too warm and the want of rain operated in keeping them back. In fact, some of the very *earliest* sown fields had to be resown owing to the seedlings having succumbed to the heat of the weather. The poppy-plant has on the whole been small in size, and not bearing more than two to three lancings.

3. After two months of apparently healthy growth the plant appeared suddenly to shrivel up, looking weak and stunted, the capsules contorted and flowering prematurely, the stems more or less discoloured, the tallest not exceeding two and a half feet in height, others again only 6 to 12 inches, the plants plucked up by me exhibiting short roots, the inefficient moisture in the soil, I presume, preventing their attaining full maturity. The season has been

an unusually dry one. The older plants became ready for incision before their time, and, as stated above, the capsules were small and bore rarely three lancings.

In ordinary seasons under favourable conditions the southern portion of my district, where this malady has occurred, yields very good averages from 5 to 10 seers the beegha. The soil is chiefly sandy with a mixture of matiyar here and there.

I can only attribute it to excessive heat and want of moisture in the ground—the plant having the appearance of figures 2 and 3, plate XIII, in your Book of Illustrations.

4. This blight was first reported to me at the close of February, and I have not observed any difference in the form of malady which is similar to that of 1874-75, and which appeared in the same localities at present affected."

W. RIDSDALE.

E.—Gorakhpur.

Extract from the Sub-Deputy Opium Agent's letter No. 367, dated 30th March 1878, to the Benares Opium Agent.

"The blight appears to have spread over the whole of the Patharwah sub-division as also over smaller portions of the remaining sub-divisions of Bhagulpore Golah and Gorakhpur.

"The blight, if it can be correctly so-called, appears to be confined almost entirely to the *bhat* soil, or, if the plant has suffered from this cause on the *bangar* soil at all, it is only in situations where from some cause or other there has been a deficiency in the supply of water.

"The cultivators state that up to the beginning of February the crop was healthy and promising, but that on the 11th there was a heavy fall of rain, which was immediately succeeded by high westerly winds which dried up the moisture before it had time to soak into the ground. The *bhat* soil, I must here explain, appears to consist principally of clay with little, if any, sand in its composition. Consequently, water is absorbed with extreme slowness on such lands, and with a high and dry wind it would, I imagine, be entirely evaporated before it could reach the roots of the poppy plants. The *bangar* soil is the *doras* or sandy loam of the other districts in these provinces, and from its porous nature it is better suited for irrigation than the above.

"The *bhat* soil, although slow to absorb water, is equally slow to part with it, and in ordinary years, when there has been the usual downpour during the rainy season, sufficient moisture is retained to suffice for the crops all the year round, and owing to this circumstance artificial irrigation is in many places quite unnecessary and is not practised.

"In the present season the rains have altogether failed, nor has there been at any time during the cold weather a sufficient fall of rain to penetrate any depth into the soil. In my opinion, therefore, the drying up of the poppy plant, for it appears to be nothing more, is entirely owing to the want of moisture in the soil, aggravated no doubt by the dry and scorching winds experienced in February. The cultivators state that the plant began to dry from the root upwards, and this seemed to be the case in the specimens I had the opportunity of examining the root, on (unintelligible) the plant longitudinally with a knife, being completely dry while the stem above ground in most cases retained more or less of the sap.

"I arrived on the scene rather late in the season, and the plant was too far gone for me to ascertain whether there was any appearance of any fungoid or other disease. Whole fields had entirely withered away, or at the most had only yielded one incision, and in a majority of cases the assamees had ploughed up their fields to sow another crop. In the villages visited, irrigation had been carried on mostly; but, as I have stated, the soil does not take the water easily, and the weather had been most unfavorable. Some of the cultivators had been fortunate enough to extract a little opium, but in no case that came under my notice was there enough in a lumber to cover the advances."

W. H.—Reg. No. 1416—101—1-6-78.

No. 201, dated Bankipore, the 3rd June 1878.

From—W. H. D'Oyly, Esq., Officiating Opium Agent, Behar,
To—The Secretary to the Board of Revenue, L. P.

With reference to your telegram of the 22nd March last, a copy of which was received with your memorandum No. 88B of the same date, I have the honor to forward in original a long and very interesting report which has been submitted by Mr. John Scott, who is on special duty at Deegah, in connection with this department.

2. Mr. Scott shows that there has been a very large increase during the past cold season in the number of insects destructive to cultivated crops, and he attributes this *unusual* increase to the light monsoon rains preceding the cold weather, which was a season of drought and maximum temperature, presenting a continuation of conditions most favourable to the preservation of the eggs and larvæ of insects. He divides these insects into two classes, which he calls the "vernal" and the "autumnal," the former of which attack the poppy plants in their earlier stages while their juices are bland and agreeable; and the latter class affect the poppy in its maturer stages, but only when the opium juices have been "more or less completely" exhausted or their secretion arrested. In *no* cases have these insects affected the yield of opium, for where the mature plants had secreted the opium juices they were *not* attacked, the juice being a very efficient protection.

3. The preventive measures suggested are *early sowings*, the effects of which are that, at the time the "vernal" class of insects appear, the plants are so far advanced that they no longer prove attractive to their early foes; and when the "autumnal" insects appear, the secretion of the opium juices proves a sufficient protection against them. I think Mr. Scott's arguments, supported as they are by the facts which have come under his observation, are convincing. He also recommends a more general observation of the system of rotation of crops, and, as a *remedial* measure when the "*vernal*" insects have commenced their depredations, he recommends a sprinkling of quicklime, mixed with ashes, which has been found most effective, excepting the case of the grub of a species of crane fly *tepula*. This insect, however, did not touch *one* of the plants of the *earlier* sowings. For the cricket and grasshopper classes he recommends liberal irrigation, which brings the insects to the surface, where their natural foes, birds, consume large numbers of them, and where they can be removed to some extent by hand-picking; sprinkling with quicklime and ashes or soot also protects the young plants.

4. To protect stores of seeds from destruction by grubs, Mr. Scott recommends sprinkling a small quantity of camphor amongst the seeds before closing the store pots; and where the seed is in heaps, to turn over and air the seed heaps, and to sift the seed occasionally, separating and destroying all affected seed, as well as the grubs which may be found. The Mainpuri Sub-Deputy Opium Agent would do well to act on the suggestions contained in paragraph 58 of Mr. Scott's report.

5. The specimens are forwarded in two boxes as received from Mr. Scott.

P. S.—The railway receipt is enclosed.

No. 504, dated, Deegah, the 28th May 1878.

From—John Scott, Esq., On special duty, Opium Department,
To—The Opium Agent of Behar.

With reference to the instructions communicated from your office, dated 22nd March, and in continuation of my letter dated the 7th April, I have the honor to forward herewith two boxes, containing in all 63 bottles of preserved specimens of the insect enemies of the poppy and other cultivated plants in this district,* with short descriptive notices of each, and a few illustrations of the injuries they cause, as also such information as I have been able to work out relating to their economy and habits.

* A separate list of which is annexed.

2. The large increase in the number of insects, destructive to cultivated crops in this country, during the past cold season, has been very striking, and especially so in those instances in which, at particular stages of growth, crops were overrun with insect forms, which had not hitherto been observed to attack them. The poppy is a case in point as having been attacked seriously, even in this district, with at least three kinds of insects new to it, and formerly confining their depredations to *pulses*, and the *mustard* or *cabbage tribe*. Again, many of the smaller pulses, as the *musoors*, *chuna*, and *khesaree*, were quite overrun and destroyed with grubs and caterpillars at an early stage of growth, while *urhur* was later infested by one or two species, the caterpillars of which pierced the capsule and destroyed the seed. In many districts this crop was most seriously damaged. Now, in the latter instances, that is the pulses, to which may be added the mustards, these insect-forms are really hereditary foes, re-appearing from season to season, so that the only matter for surprise is their sudden appearance in such unprecedentedly large numbers. Well, I think I may safely say that this is at least largely due to the very light moonsoon rains, that is

those preceding the cold weather, which has moreover been season of drought, with a high average, indeed maximum, temperature prevailing ; we have thus a continuation of conditions most favourable to the preservation of the eggs and larva of insects. It should not be overlooked, however, that a steady increase from year to year of the insect enemies of plants probably obtains in India from the immense and annual increase of area under tillage, as also the utter absence of any regular system of crop-rotation, so that, from year to year, each insect has ready to hand its more or less *special food-stuff*. Now, a regular system of rotation of cereals generally with the pulses, &c., would to a certainty impair fecundity, as few indeed of the insects with which our cultivated crops have to contend find a common food-stuff on the above tribes, *i.e.* on *cereals* and *pulses*. By adopting, then, such a practice over large areas, and considering that the *grub*, *maggot*, and *caterpillar-forms* of the insects are as a rule the most serious ravagers of cultivated crops in this country, a large percentage might thus be expected to be starved from season to season, ere they reached their particular food-stuff.

3. Again, in extending the area of cultivation, the destruction of forests is always more or less largely involved, and thus indirectly favours the preservation and increase of the insect ravagers of cultivated plants in two ways : *first*, in lowering the humidity of the seasons or climate ; and *secondly*, as depriving insectivorous birds of their roosts, and thus driving them off in centrifugal lines from the centres of cultivation. I think there can thus be no question that a system of rotation of crops as suggested, a judicious conservation and extension of forest land, and the preservation of all kinds of insectivorous birds, are plainly the only really efficient and practicable modes of checking the increase and keeping in some control the insect depredators of the plants of cultivation.

4. Altogether irrespective, or indeed in spite of the adoption of these evidently preventive measures there are none the less certain unknown causes or conditions which on the one hand give quite an epidemic character to the increase and diffusion of those insects which attack plants under cultivation, and again on the other hand tend to their decimation. Many such illustrations of the unaccountable appearance of swarms of destructive insects have been recorded, and it may not be out of place here to re-state a few. Thus the late Sir C. Lyell observes that the peculiarity of their insect-agency consists in their power of suddenly multiplying their numbers to a degree which could only be accomplished in a considerable lapse of time in any of the larger animals, and then as instantaneously relapsing without the intervention of any violent disturbing cause into their former insignificance.

"A scanty number of minute individuals, to be detected only by careful research, are ready in a few days, weeks, or months, to give birth to myriads which may repress any degree of monopoly in another species.....But no sooner has the destroying commission been executed than the gigantic power becomes dormant, each of the mighty host soon reaches the term of its transient existence, and the season arrives when the whole species passes naturally into the egg, and thence into the larva and pupa states. In this defenceless condition it may be destroyed either by the elements, or by the augmentation of some of its numerous foes, which may prey upon it in the early stages of its transformation ; or it often happens that in the following year the season proves unfavourable to the hatching of the eggs or the development of the pupa.

"Mr. Curtis, referring to the *aphides*, observes that, as among caterpillars we find some that are constantly and unalterably attached to one or more particular species of plants, and others that feed indiscriminately on most sorts of herbage, so it is precisely with the aphides, some are particular, others more general feeders ; and as they resemble other insects in this respect, so they do also in being more abundant in some years than in others. In 1793 they were the chief, and in 1798 the sole, cause of the failure of the hops. In 1794, a season almost unparalleled for drought, the hop was perfectly free from them, while peas and beans, especially the former, suffered very much from their depredations.

"In the latter part of the last century an *ant* (*Formica sacchapivora*), most destructive to the sugarcane, appeared in such infinite hosts in the island of Grenada, as to put a stop to the cultivation of that plant. Their numbers were incredible. The plantations and roads were filled with them ; many domestic quadrupeds, together with rats, mice, and reptiles, even birds, perished in consequence of this plague. It was not till 1780 that they were at length annihilated by torrents of rain." *Principles of Geology*, 10th Edition, volume II, page 437, *et. seq.*

5. The insect foes of cultivated plants in this country have in but a very few cases been as yet specifically determined, and even of those little is known of their habits and economy. The following remarks therefore on these subjects are necessarily meagre, as consisting of casual, rather than systematic, personal observations during the few seasons that I have been temporarily attached to the Opium Department. I will first notice the characters, transformations, habits, and economy of the species which have attacked the poppy plant during the past season. They may be disposed of under two heads, from differences in the stages of the plant's development at which they attack and continue their depredations. Thus we have a *vernal* set which affect the plant from the period of germination till the completion of the root-leaf system. Now it is important to observe that during this period the juices are sufficiently bland and agreeable to permit of their use as salad with young lettuce, &c. The other

series are *autumnal*, and affect the plant in its maturer stages only, and this after the more or less complete exhaustion of the opium juices, which, when present in a normal state of concentration, afford a most efficient protection from all such foes. The great prevalence and unusually early appearance this season of the ordinary species, as also of others not hitherto observed to attack the opium poppy, can only, as I believe, be due to an absolute deficiency or extreme dilution of the opium juices in the plant, and of this unfortunately the general harvest results afford unequivocal evidence.

6. I shall now treat of the particular species, and, first, of the vernal series of the plants' foes. These are in all eight, viz. a caterpillar of the genus *noctua*, the grub of a cranefly, *tipula*, the common field and house crickets, *Acheta campestris* and *A. domesticus*, and the oo-chingrah, goor-gooriah or mole cricket, *gryllotalpas vulgaris*, and a grasshopper.

7. *Noctua species.*—In the illustrations accompanying my annual report for the season 1873-74 (plate XVI, figure 4), I have given figures of this insect in the caterpillar, pupa, (with and without its clay-cell), and perfect forms. Unfortunately I have been unable to find out where its eggs are deposited and hatched, though I strongly suspect, from the sudden appearance of such numbers of the young small-sized caterpillar form over large areas in November and December, simultaneously with the germination of the poppy, that the soil is their hatch, as it certainly is their nursery. This part of the habits and economy of insects is, I need scarcely remark, the most difficult of all to ascertain; and even in Europe, where the insect enemies of cultivated plants have long been specially studied by many eminent entomologists, that of many common and destructive forms is unknown. This was the case only a very few years ago (and so far as I know is yet) with that common pest of field and garden crops, the heart and dart-moth, *noctua exclamationis*. An allied species, the corn dart-moth, *noctua segetum*, it has been stated, deposits her eggs in the soil In so far as memory serves me, I may observe here that the species infesting the young poppy crops is scarcely different from the European *noctua segetum*, and is I think but a variety of that species. The figures referred to in my illustrations exhibit the male form only with its slightly pectinated horns. In the caterpillar stage it attacks the young poppy, and if at all abundant commits great havoc, as it has the evil habit of simply gnawing out the stalk close to the surface of the soil, and thus destroying one plant proceeds to another. Its mischievous powers will be understood when we state that a single caterpillar in the course of a night's raid will thus cut down from fifty to a hundred or more plants. The first cut of the fresh and soft juicy and uninjured stock is its *morcean friaud*, the upper portion, as also the leaves and the roots, being as a rule passed over to dry and wither. It is the "*khumwah*" of the assamees, and though, as a rule, one of the most destructive of the insect foes of the young poppy, it not unfrequently extends its ravages to the adjoining crops of mustards, pulses, &c., during their earlier stages of growth. During the last season it caused for a short period much damage to the later sown crops in the gardens here, but was ultimately checked by a few applications of a mixture of quicklime and ashes. I observed that it caused considerable injury to the assamees crops in this district. In every case, however, the *later sowings* have alone been attacked; and in the gardens here, while prevalent on the late crops, it never affected the adjoining crops of *earlier* and *more* advanced plant. Early sowing is thus evidently one mode of securing a certain immunity to the poppy from this insect's ravages.

8. As I have preserved no specimens of this insect, I will quote here the description given in previous reports. The caterpillar is nearly cylindrical, from $1\frac{1}{4}$ to 2 inches long, and rather stout in porportion to its length. It is of a dull greyish-brown colour (blackish-brown when full grown) with lateral stripes of a dull green colour. The head is horny and of an orange-brown colour, as is the first thoracic segment, the other segments having each four little tubercles, bearing short hairs, the stigmata or breathing pores. When fully mature it buries itself in the soil, to a depth of from two to six inches, and there constructs a firm, irregularly oblong cell of earth $1\frac{1}{2}$ to 2 inches long, by $\frac{3}{4}$ to $1\frac{1}{4}$ in diameter, in which it passes from the larva to the pupa state. I have been unable to ascertain the period it naturally remains in this state; under artificial conditions, the metamorphosis was completed, and the perfect insects made their appearance in from twenty to twenty-five days. This is probably about the time naturally occupied, as the moth is common enough from about the beginning of February to the middle of March. During this period of the past season, indeed, it was quite an evening pest, so swarmingly did they flit and hover around the lamps in rooms and verandah. The moths vary in size, the expanse of wing being thus from $1\frac{1}{4}$ to 2 inches; the body of a dull grey-brown, the upper wings variously streaked and occillated on a smoky-brown ground; the under wings are ash-grey, with brown tinted margins and nervures in the male, and of a uniform dark-brown in the females.

9. There are I believe annually two generations of moths, one in February and March, and which in the caterpillar state are the foes of the young poppy; the other in August, and disappearing in the early part of September, the caterpillar form of which feed chiefly on the young crops of the rainy season's legumes or pulses. The only practical means of subduing the caterpillar on the young crops of poppy, pulses, &c., as I have already stated is to sprinkle them over in the evening with quicklime, or a mixture of this and ashes. One or two applications will generally prove effective.

10. I have now to notice a very serious enemy of the young poppy, and this, one which within my experience has not hitherto affected this plant: it is the grub of a species of cranefly, *tipula*. These grubs are about three-fourths of an inch long, stout in proportion, and though destitute of feet, are by no means inagile in their movements. The head is small (relatively to the thickness of the body), black and horny, with similarly coloured keenly incisive jaws. The colour of the body varies from a dirty or clayey-brown to greyish-black. Appearing early in December, these grubs continue their depredations until about the middle of January, when they bury themselves in the soil and change to pupæ, which are about the same length as the grub, and form a thin, oblong case of a dull brownish colour. The metamorphosis is completed, and the perfect insect appears in February and March, during which period it was very abundant last season, haunting the poppy and other crops. The body of the gnat is about three-fourths of an inch long, the wing expanse one inch: the wings are of a dull yellow, with the nervures of a paler and clearer colour; the abdomen fusiform barred, and spotted with black on a dull yellowish ground.

11. The grub of this gnat caused much injury to the later sown crop in the Deegah gardens. In December and the early part of January it really swarmed in the soil and formed a square foot of land in many parts; there was no difficulty in picking up in the mornings from ten to twenty full grown grubs, which had been fully employed "eating off" the young poppy during the night. Applications of quicklime, and even lime-water, were alike ineffective in suppressing them; they have a thick and firm skin, which apparently enables them to resist the usual destructive or suppressive action of such applications to larvæ. I really know of no practical means of subduing this pest; the slow, laborious, and generally effective mode of hand-picking is even inapplicable, not only from the small size of the grub, but from its working indifferently on, and under, the surface of the soil. Its depredations extend from the first stages of germination until the plant has attained from one to two inches in height. The later sowings in the Deegah gardens, which (from a failing supply of water I was unable to irrigate until late in November) germinated in the beginning of December, were destroyed piecemeal by this pest, in spite of any measures that I could adopt with a view to subdue it. It was so far satisfactory to observe, however, that its ravages were entirely confined to the late crops; the earlier and more advanced plant, at the period of its appearance, had a common immunity from it. The Board's communication reached me too late in the season to secure specimens for preservation.

12. The next series of foes which I have to notice attack the poppy at a more advanced stage, and this as a rule from the latter part of November to the middle of December, in the case of the early crops, and successively directing their depredations to the later crops until about the middle of January. These are the well-known crickets, members of the genus *Acheta*, and apparently represented by three or four distinct species in our poppy-fields, comprising *A. campestris*, *A. domestica*, and another species, or it may be a variety of the former. Anyhow, however distinguished systematically, they have a habit in common, in so far as I have observed, of confining their attacks on the plant to the later stages of development of its root-leaf system. They rarely, if ever, attack the plant in the germinating stage, or indeed previous to its having produced several cycles of root-leaves (and thus attained considerable vigour), continuing their depredations more or less until the stem begins to shoot out. Their period of hostility is thus fortunately of short duration, though in dry and hot seasons, as the past, when they always most abound, it is quite sufficient to enable them to effect considerable injury to the crops, indiscriminately feeding on the parts of the leaf or the stem. They are the *Jhengur* of the Hindustanees, and obnoxious alike for their destructiveness in the house, the garden, and the field. A set of preserved specimens of each of these species is forwarded in phials under Nos. 1 to 3 of my collection.

13. In an ally of the true grasshoppers the young poppy had a new foe last season. This is an odd and dirty-looking insect, about an inch in length, of a somewhat rhomboidal outline, due to the enlarged thorax, more marked in the female than the male form, the abdomen being more elongated in the latter. It has a rough. warty, or shagreened skin of a dirty ash-grey color (very protective, however, as rendering it of difficult observation when at rest in its soil haunts) above, whitish below, with two black spots on each segment of the thorax and abdomen. It is the "Kadhya" or "Gudhia" of the Hindustanees, and always, I learn, more or less troublesome to various products of their gardens and fields. Prior to the late season, however, it had not been observed to affect the poppy. A series of specimensof this insect in various stages of development are forwarded herewith,—*vide* phial under No. 4.

14. The next insect which calls for notice here is a true grasshopper, *Gryllus*, the "Phanga," or "Phunge" of the assamees. From year to year the young poppy, *pro tempore* is one of its many host-plants, always sustaining more or less local damage from its attack; while with every recurrent season of heat and drought they multiply and increase rapidly, extending their depredations, and infesting the crops over large areas. It is a voracious feeder when full grown, cropping with equal gusto the leaves and stalks of young plants. The phial No. 5 contains a series of young specimens of this destructive grasshopper.

15. The best modes of subduing the above insects of the cricket and grasshopper family, as it appears to me, is first the preservation of insectivorous birds—*crows* and *mynas* especially are their incessant foes—facilitating their operations by liberal irrigation of the

crops which brings the crickets to the surface of the soil, and makes the grasshoppers skip out from their leafy harbourings. Hand-picking is also a most effective mode of lessening these insects, and might with a little extra labour to the assamees be regularly practised, both specially and simultaneously with the operations of thinning, weeding, and watering the plant. Another mode which I find very useful is to dust the young plants freely in the evening with quicklime and wood-ashes, separately or mixed in equal proportions. Soot also, where available, may be similarly applied with great advantage.

16. The mole-cricket or earth-crab, *Gryllotalpa vulgaris*, the "Goorghoorgah" of the Hindustanees. This is a very widely diffused enemy of plants under cultivation, being more or less common throughout the temperate and tropical regions of the Old World. It is a destructive creature of nocturnal habits, and where at all common commits sad havoc on the vegetable products surrounding its subterranean retreats. It prefers dry habitats, or at least those which are not subject to be regularly irrigated or flooded. As regards the poppy, it is likely thus to be a more serious foe to the plant on unirrigated than irrigated lands. Favoured, however, by heat and drought last season, even under the latter conditions I found it causing considerable damage to the crop in a few instances, they having apparently ensconced themselves in sufficiently deep and circuitous channels to be secure from other than very partial floodings from irrigation owing to the rapid absorption of water by a dry and parching soil. They make very extensive and variously directed underground channels, so that digging them out is a tedious and troublesome work. The most practical mode is to thoroughly flood each separate haunt, and await the appearance of the insect, when it can readily be caught and destroyed. I may add that, if not kept in check by artificial modes, they will be found to increase rapidly, as, with the exception of the shrews, hedge-hogs, and field-mice, none of which are very common in poppy districts, they have really few natural enemies, and a single brood consists of from two to three hundred individuals. The phial No. 6 of the accompanying set contains specimens of this insect.

17. The above, then, comprise alike the regular and casual foes of the poppy plant in its earlier stages of growth which have come under my personal observations. Their period of attack extends from the germination of the seed until the young plant has nearly completed its root-leaf stage. They rarely make an appearance before the middle of November, and even then sparingly increasing towards the close, attaining a maximum by the middle of December, then rapidly disappearing. This, I may remark, but for late sowings and late crops, would occur much earlier, as it is only on the latter that their depredations are then continued. Indeed, the early sown crop, that is plant from seed which has germinated before the end of October, rarely suffers at all from any of the above insects, inasmuch as, if on good soil, and regularly and sufficiently irrigated, it will have attained a stage of development in which its leaves and other parts are distasteful to them. That this is likely to be the true explanation will, I think, be readily admitted, when we reflect that the leaves and parts of the plants in its earlier stages are tender, subacid, and very slightly pungent; whereas later, and that even in the stage above indicated, they have a bitter, pungent, long persisting nauseous taste, which may well give them a special immunity from their earlier insect foes. Goats even, which greedily enough feed on the young plant in the first stages, will avoid it in the later. The thinning of the young plants, when from three to four inches high, are generally collected by the assamees, who use them as a vegetable, giving any surplus to their goats and other cattle. There can thus I think be no doubt that the opium juices serve a protective purpose in the plants' economy. From this point of view, then, it would further profit the plant if these bitter, acrid and nauseous juices were secreted by the germinating plantlet, and for reasons which will subsequently be given, even if elaborated by and fixed in the seed.

18. Under this head I will now only add that, if we may not altogether avoid the attacks of the above-noticed insects on the poppy, we may at least greatly mitigate their injurious action by *early* sowing. This, as it appears to me, is the most efficient, as it certainly is the most facile, mode that can be recommended. Its advantages are especially apparent in dry seasons like the last with an abounding of injurious insects; we might everywhere see, in adjoining and parallel strips, crops of early and late sown plant in which, while the latter was more or less seriously infested with insects, the former was wholly unaffected. I had a striking example of this in the Deegah gardens on parallel strips of land upwards of 900 feet in length. The neighbouring crops of the assamees also afforded many striking illustrations.

19. I now pass on to the second, or, as I have termed them, the *autumnal* series of the poppy's insect foes, that is, those which attack the plant in its maturing and mature stages. Now, as already stated, the early or *vernal* insect foes of the poppy make their first attack about the middle of November, and passing over to successional or late crops thus continue their depredations until late in December. I can understand, however, that in exceptional cases from poverty of soil and deficient irrigation seeds sown early in November, of tardy germination and growth, may still be subject to the cricket and grasshopper pests, as will also doubtless plant from sowings made in the *first week of December*, as appears to have been the case in some instances of crops affected with blight, improperly so called, and sent to me for examination from different districts of the Benares Agency.

20. With the disappearance, then, of these cricket and grasshopper foes of the young plant in December they have a common immunity from all forms of insect injurois until the beginning of March, the period of re-attack being as a rule determined by the state of maturation of the plant, and especially the concentration, quantity, and diffusion of the opium juices in the parts of the plant. Everybody, during the past season, has been struck with the numbers and kinds of caterpillars which have attacked the green leaves and immature capsules of the poppy. Again, the species common to the poppy appeared much earlier than usual, I having observed it on plants in the gardens here about the middle of February. From Mr. Darwin's suggestion to me, as to the probable function of the milk-sap or opium juices, I particularly examined those immature plants on which I observed this and other caterpillars, and, without exception, found that their parts contained little or no milk-juice, and that this even, where present, was of a thin and watery consistence. This I think explains the early appearance and increase in variety of insects which have been observed to feed on the green parts of the late crop of poppy. But of this I will treat more particularly in a subsequent part of the report. In the meantime, I will briefly describe the characters, the general habits and economy of the several kinds of insects that I have found attacking the late crop of poppy in its maturing stage.

21. I will first notice a species which, as it appears to me, at some period subsequent to the introduction of the opium poppy to Indian agriculture, has affected it, and ultimately become its hereditary foe. I infer this from the fact that not unfrequently from 70 to 90 per cent of the insects are entrapped and victimised in the capsules. The contents of the poppy capsule, that is the seeds, are evidently not an original, feral, or natural food-stuff of this insect. I shall, however, make this more clear in a subsequent paragraph, and will now more particularly direct attention to its general characters. From recent examinations it appears to me now to be a member of the genus *memstra*, rather than that of noctua, to which I referred it in my Manual of Opium Husbandry. Anyhow, to whatever genus it may ultimately be referred, we know that the poppy is now its favourite host-plant, and presuming, as I believe it is, an undescribed species, it may well be called the *poppy-moth*, and thus provisionally *mamestra papaverorum*.

22. It is of course in the caterpillar state that it attacks the poppy. First as regards the eggs: these I believe I have found, but having failed in their artificial hatchment, I cannot positively identify them. These are of an oblong shape, of a dull greenish colour, rather more than a line in length and deposited bi-serially on the lower surface of the poppy leaves, each "set" consisting of from 60 to 100 eggs. They are deposited in March and April in part. I believe these afford a brood which feed on the young crops of legumes, &c., which spring up in June and July. The fact that we have this moth first in spring, and again in autumn, clearly enough shows that there are at least two generations of them during the year. The *caterpillar* as it bursts from the egg is very small and thin, in colour of a pale greyish green. It grows rapidly, assumes a nearly uniform olive-green colour, and as it attains maturity, ash-grey, with a medial and lateral stripes of a pale reddish-brown. When full grown it is from an inch to an inch and a half long, and about the thickness of a goose-quill. It has six sharp-pointed pectoral feet, eight abdominal and two anal. The pupa is of a dull chestnut-brown, very generally found in the poppy capsule, and there, as a rule, hoplessly impaled, the hole which the caterpillar made on entering the capsule being rarely sufficient for the exit of the moth. Occasionally they may be found in small cocoons attached to the lower surface of the leaves of the poppy with the margin folded over them. This is no doubt the natural habit of the species in this part of its economy, as metamorphoses in the poppy capsule are simply as a rule suicidal. The moth presents three sexual forms, one male and two females, chiefly distinguished by colour differences. The *male form* is the largest of the set; the wing expanse is from $1\frac{1}{2}$ to $1\frac{3}{4}$ inches. The moth is of a pale orange colour, the wings in all reposing horizontally; the horns are bristle-like, rather longer and delicately pectinated in the male. The upper and under wings are of a pale saffron colour, with a broad intramarginal band of amber-brown, and a single spot varying in size and form of the same colour on each of the upper wings. The *second form*, *female*, and the more common of these, is altogether of a darker colour than the preceding and of smaller size; the wing expanse is from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches. The upper wings are tawny-brown, the lower ash-grey, both having a slightly intra-marginal band of a dull greyish-brown colour, with a few small irregular discal spots of the same colour. The *third form*, also female, differs only in colour from the preceding, and this simply in dilution, the ground colour being a dull ash-grey, with intra-marginal band and discal spots of a dull smoky-brown colour. It thus tends to an albinos state. Such, then, are the general characters of the poppy-moth, *mamestra papaverorum*. I will now give a more particular sketch of its habits.

23. It seems to me to be very generally diffused through Upper Bengal, the North-Western Provinces and the Punjab, and from year to year more or less common on the maturing poppy crops in both agencies. It also attacks various pulses, especially the *musoors*, *chuna*, and *mutur*, less frequently *urhur*, boring into the capsules and feeding on the seeds. The caterpillars in their earlier stages of growth confine themselves mainly to the lower surface of the leaves of the maturing poppy, gnawing the cuticle and occasionally the margins. They invariably make their first appearance on

the lower leaves, which is probably due to their having been hatched in the soil. Increasing in size and presenting variations in colour as already noted, it finds its way from the lower to the upper leaves, and finally the capsule, which it penetrates, feeds on the seed, and if in quantity sufficient for its growth and development, there it remains and passes into the pupa state, and ultimately the perfect form, from which, however, it rarely escapes, and thus dies alike prematurely and infertilely. In this we have a very material check on the propagation and increase of this moth; scarcely *one* in *ten* I believe escapes, and moreover they have vigilant foes in the *mynas*, which, perching on the bored capsules, watch the operations of the caterpillar, and should it at all emerge from, or even appear at the mouth of, the hole by which it originally penetrated the capsule, it at once strikes and rarely fails in withdrawing it, either wholly or in part. It is thus we find, in breaking up the mature capsules, various remains of this caterpillar. As roughly illustrating the decimating results in this insect's affecting and undergoing its later metamorphosis in the poppy capsule, I have thought it worth while to forward herewith a bottle of preserved specimens in caterpillars, pupa and moth forms, thus entrapped and destroyed in the capsules on a small plot, *five cottahs* only, in the gardens here. The specimens referred to are contained in phial No. 7 of the collection.

24. From these observations it is evident that this insect is not normally a poppy-seed feeder, as already remarked, but has been accustomed to plants with capsules of a very different mechanism. Normally, I believe, they are feeders on the common cold weather pulses in the first brood of the season; and again, in their second brood, on certain members of the same family peculiar to the rainy season. Now, all these I need scarcely observe have dehiscent capsules, that is split open for the discharge of their seeds. Here, then, the insect is perfectly secure; it feeds on the seeds, attains its maturity, undergoes metamorphosis in the capsule, and ere this stage, the pupa is completed, the capsule has split open, and the moth on bursting from the pupa is then perfectly free. On the other hand, in the case of the opium poppy, the capsule is of the indehiscent class, and to the last presents no opening for the discharge of its seeds, this being wholly dependent on the natural decay of the parts of the capsule. It is thus easy to see how this moth falls a victim to its natural habits in extending them to the poppy, as in all instances, I believe, in which there is a sufficiency of seed in the capsule to sustain the caterpillars until they are full grown, they remain and pass into the pupa state. Again, in small capsules containing an insufficiency of seed, we find them making their egress, and then not unfrequently attacking and boring into the stalks of the plant, ultimately, however, withdrawing and forming cocoons on the lower surface of the leaves in which they pass into the pupa state. In one of the phials containing specimens of this insect I have included small portions of the stem bored by caterpillars.

25. As I have stated, the caterpillar in its different stages of growth attacks both leaves and capsules, the latter, however, as it would appear only to reach the seeds of the poppy of which it seems to be particularly fond. From imperfect fertilization, however, and a deficiency or absence of perfect seeds in the capsule, I find that this caterpillar, after having made repeated borings in the capsule walls, ultimately gnaws and feeds on them. This was very strikingly exhibited in a bundle of specimens sent to me by the Sub-Deputy Opium Agent of Lucknow. In no instance have I observed poppy capsules in the field thus injured by insects, which, but for the occasional irregularly gnawed portions, have all the appearance of having been subjected to a discharge of shot. I have preserved a few of these capsules, and forward them in a labelled bottle with the insect collection, as very strikingly showing the injury they occasionally effect on the capsule. I should here observe, however, that capsules thus gnawed and riddled must have contained few or no good seeds. I see plainly enough that this has been the case with those now before me, the seeds having been quite abortive in all that I have examined. As already remarked, it is but in a futile search for seeds that the caterpillar thus gnaws and perforates the capsule.

26. I would now, however, particularly observe that, from the first attack of the young caterpillar on the lower leaves during its growth, and ascent to the capsule and penetration to the seeds, the several plants had in each case, prior to its invasion, been more or less completely depleted of their protective milk-juice, or contained it only in a very diluted and diffused condition. I can speak from careful, and now indeed extensive, observation that neither this caterpillar, nor any other which I have yet made experiments with, will attack the parts of the opium poppy when any way replete with a normally concentrated milk-sap. Casual observers indeed remark on their attacking the plant when all its parts are green and immature, thus unwarrantably assuming its repleteness with the opium juices. A green and immature plant, however, is no warranty whatever for the presence of the opium juices; the assamees know this well, and the late season's crop (it would appear more than all others which they have seen or heard of) to their grief and dismay has confirmed it. We need thus scarcely be surprised at the early and increased train of the crop's insect foes. It is important to observe, however, that though seriously damaging and diminishing the seed produce, these insect pests have in no material way, I believe, affected that of opium. As already observed, the *presence* of normally concentrated opium juices in the plant secures it most effectively from the various insect foes which more or less infest it; first, in the early stage, when the juices are more or less bland, and again in the maturing stage, when the

opium juices are exhausted. There can thus I think be no question as to the protective function exercised by the opium juices; they are indeed very perfect while they last, but fail utterly as we have shown at two critical stages—that of the germination of the seed and early growth of the young plant; and again in its maturation. The specimens of this insect are contained in four phials, marked 7, 7*a*, 7*b*, and 7*c*, and consist of eggs, pupæ, larvæ and moth-forms.

27. I have now to notice a species of *noctua*, found on the poppy in the Government gardens at Meetapore. It feeds on the leaves of the plants only, and does not appear to attack the capsule or seeds. The caterpillar when full grown is of a dull green with costal and lateral stripes of a tawny-brown colour; they are from 1 to 1½ inches in length, have a small brown horny head, six pectoral, eight abdominal, and two anal feet. They pass into the pupa state in a thin webby cocoon, formed on the lower surface of the poppy leaves. The moth emerges in from 14 to 20 days. It is the largest which I have yet found affecting the poppy, measuring about 2½ inches from tip to tip of the forewings. These are of a dull yellowish-brown, clouded with olive-green, the margins pale-brown, and marked with two dark spots on their front edge; and a few other small irregular spots on the disc. The lower wings are of a paler-colour than the above with a broad, irregular inter-marginal band of amber-brown. This species does not ordinarily affect the poppy, and I found it only in the Meetapore experimental garden. It is usually more or less common in gardens, feeding on the leaves of the cabbage, both young and full grown plants, ultimately penetrating to the core where it nestles, and passes in to the pupa state. As in the above instance, then, it is only likely to be found on poppy crops more or less surrounded by private gardens. I have to observe, however, that though confining its attack to the green leaves of the poppy, this is only after they have been exhausted of their milk-sap. This is an important fact, as indicating that the insect is innocent of injury to the plant as an opium-producer.

28. The poppy plant in this district, as I presume elsewhere, had a new and destructive insect enemy in a species of *Bombyx*, which hitherto appears to have mainly confined its depredations to the castor-oil plant, and the Tiliayakura of the natives. The eggs of this species are usually deposited in rather flimsy cocoons on the lower surface of the leaves of the latter plant; each brood comprises upwards of 300 individuals, and for a few days after the young caterpillars emerge from the eggs, they form a dense wriggling, maggot-like swarm. They do not then exceed one line in length, thread-like and of a greyish-white colour. They rapidly increase in size, are extremely voracious, the stronger, at least in the case of those which I reared artifically, attacking and devouring the weaker. They continued this habit until nearly full grown, though regularly supplied with green and fresh leaves of the poppy. Of the two broods which I reared, I am sure that at the very least 75 per cent. were thus destroyed. In this internecine warfare their increase is fortunately largely checked, as they appear to be almost exempt from the attacks of insectivorous birds. *Mynas* shun them, and this will scarcely be a matter for surprise after having seen the full grown larva (it is the Bhooa of the Hindustanees). This indeed looks anything but a titbit *un morceau friand* for any of the insectivorous class. It is from 1½ to 2 inches in length and about the thickness of a swan's quill: the ground colour is a dull olive-green, with dorsal and lateral stripes of a blackish-brown colour: the stigmata or breathing holes are of an ash-grey colour, and the back and sides are alike covered with fascicles of long silky hairs, those of the head and anus of a blackish-brown, and of a silvery-grey colour on the back. The head is black and horny: they are furnished with 16 feet—six sharp, pointed and hairy, pectoral; eight stout abdominal, and two anal, all of which are more fleshy than the pectoral with pectinated disc-like extremities. Those which I reared enclosed themselves in a rather flimsy, but viscous cocoon amongst the poppy-seeds which, adhering readily to it, seem a thick and dense mass of an oblong shape. The moths emerged in from 15 to 20 days. They are of a pale buff colour, the upper wings having a single black spot on the lower surface near the front edge, the lower wings are rather with solitary discal and marginal spot of black, the antennæ are black and bipectinate, the eyes and feelers black, the legs brown, with the exception of the thighs, which are orange-red, as also the body of the male, the female being grey brown. It measures from tip to tip of forewings 1¼ inches. As already observed, this insect, as a rule, mainly confines its depredations to the castor-oil plant, *Recinus communis*, and the Tiliayakura, *Cocculus acuminatus*, plants belonging to widely distinct orders, and possessing very different qualities. The Burobhooa, however, feeds indifferently on the leaves of both, so that it need not surprise us that it has this season invaded the poppy (as everywhere growing in proximity to its usual host plants) considering that much of it contained little or no milk-sap, and all, after its exhaustion, were quite green and far from mature, thus affording an abundant supply of slightly acid, subacrid foliage of easy mastication. It attacks no part of the plant containing the milk-sap, unless indeed it be present in a very dilute or diffused state. It thus in no way affects the opium secretions of the plants.

29. I have remarked that this insect, I should say the larva-form, has a great immunity from all the common insectivorous bird. This we might be at first disposed to attribute simply to its being so closely covered with long, erect hairs, but then again we know that these birds do eat other kinds of similarly shaggy haired and really repulsive-looking caterpillars, all of course being flexile and possessing no *stinging properties*. The real explanation,

as it appears to me, is that another, but smaller cater-pillar, very similar in colour and shagginess, but differing in this, that the hairs are brittle, and cause intolerable itching, affects also the castor-oil plant. Moreover, it not only causes excessive urtication, when applied externally, but internally it provokes very dangerous and not unfrequently fatal results. Goats and buffaloes, as being fond of the leaves of the castor-oil plant, are so affected, in occasionally swallowing one or more of these caterpillars with the leaves. The first symptoms are swelling and inflammation of the bowels, followed by excessive purging, which, if not arrested, not unfrequently causes the animal's death. We have thus, as it would appear, an instance of mimicry an innocuous caterpillar, resembling and affecting the same plant as that of a really noxious form, which may explain the immunity of the other form from the attacks of *mynas* and other insectivorous birds. I have not succeeded in tracing this caterpillar to its perfect form; for comparison with the other, however, and subsequent identification, I supplement the other set 9, 9*a*, and 9*b* of the Burobhooa with the latter, the Bhooa of the Hindustanees. This phial is No. X of my collection. It is especially noteworthy, considering the excess in kinds and numbers which have affected the late crop of poppy, that while this caterpillar was most abundant in the preceding season 1877, it has this season been rare in the extreme. I cannot say of course whether this has been general or not; but I do know from personal observations and inquiry that it holds for this district.

30. The caterpillar of a small moth, which I cannot even generically determine, may now be noticed as a new or very casual foe of the poppy. It usually affects the cabbage tribe, especially mustard and radish. The native cultivators, however, so far as I can learn, have given it no specific name, but pass it with many others as a *kala peelu*, or *jhânjhâ*. For all this, however, it not unfrequently commits sad havoc on their crops. It has done so at least during the late cold season. Mustard has suffered severely from it, as have others of the cabbage tribe, and it has moreover extended its depredations to the poppy plant. The specimens of the insect forwarded were taken from that plant in the Deegah gardens, and I do not doubt that it will be found to be one of those new foes observed by district officers, and which in some instances have stripped the plant of every green leaf. This may well be, as it is certainly, the most destructive and voracious of all the plant foes known to me. It is fortunate, indeed, that its ravages are confined to the maturing opium-depleted plant, as they would commit great havoc on the young crops.

31. The female appears generally to lay her eggs on the lower surface of the leaf of the plants they affect, be it mustard, the radish, &c., or poppy, depositing them in a single mass, and covering them with a thin web. The eggs are small, of a linear-oblong shape, and each brood consists of from 300 to 400 The caterpillars appear to be hatched from about the end of February till late in March. They are very minute, scarcely a line in length, thread-shaped, and of an ash-grey colour. For a day or two after they are hatched they form a dense maggot-like swarm from their minute size and form, their colour and wriggling motions. They grow very rapidly, those which I reared attained their full size and passed into the pupa state on the twelfth day from their birth. In their earlier stages of growth they wage a constant internecine war, the stronger devouring the weaker. I was much struck, on first observing this singularly unnatural habit in this and the preceding species, as I have no recollection of its having been noticed in treatises on those insects injurious to cultivated plants. It deserves special notice, as being an effective and innate check on the increase of this insect, and this really of a more severe nature than that which they are subject to by the attacks of the various insectivorous animals. Judging from the rate of mutual destruction in the broods I reared, all liberally and regularly supplied with green and fresh leaves, I do not think that more than 20 to 30 per cent. attain their mature or pupa stage. Even this comparatively low percentage is subject to considerable reduction by the attacks of insectivorous birds, &c. Thus, fortunately for the agriculturist, their multiplication is severely controlled.

32. The caterpillar, when full grown, is from $1\frac{1}{4}$ to $1\frac{3}{4}$ inches in length, and quite as thick as a swan's quill. It is then most voracious. Two caterpillars in a single day will devour a full-sized leaf of the poppy, leaving at least but the stouter parts of the *costæ* or main ribs. The colour above is brown-black, with deeper coloured spots on each segment and dorsal, and costal stripes of an ash-grey colour; below, with the exception of the head and anal parts, which are black, the colour is ash-grey. On the head and anus there are a few short, solitary hairs, the other parts perfectly glabrous: it has in all 16 feet. six pectoral, sharp-pointed and horny, eight abdominal, and two anal, short, stout and fleshy, with discoid extremities The caterpillar changes to a short, ovate-oblong pupa, of a reddish brown colour, with a costal line of black spots on the segments. From the pupa state the perfect insect emerges in from 10 to 15 days. The moth is small relatively to the bulk of the caterpillar form: the forewings, from tip to tip, measuring only $1\frac{1}{4}$ inches, and the slender ovate-oblong body seven lines. The upper wings are pearl-grey, with a broad intra-marginal band, and more or less freckled with shades of metallic brown; the lower wings are of a uniform silver-grey, with faint intra-marginal strips of a darker colour. These moths appear about the end of March, and this season were then very abundant in the evening; numbers of them might be seen hovering round and lighting on the verandah lamps. The specimens of this insect are forwarded in four phials, marked 11 to 11*c*. In phial No. XI I have also included small portions of poppy leaves reduced almost to a skeleton form by the young

caterpillars. They always operate from the lower surface, gnawing off the cuticle and softer inner tissues, leaving the midrib, veins, and upper cuticle as shown in the above specimens. The full grown caterpillar, with the exception of the stouter parts of the midrib and veins, devour the whole leaf, and ultimately attack the seed-capsule and its contents.

33. There is but one other caterpillar-form that I have to notice as having extended its depredations from its ordinary host-plants (*musoors*, *cheena*, and *muturs*) to the poppy during the late season. It is probably a member of the genus *noctua*. I have not been able to follow out the metamorphosis of this insect; the caterpillars I kept did not thrive, though they had both poppy and *musoor* leaves to feed upon, and of the few that passed into the pupa state, all died before their emergence in the perfect form. I thus know only the larva and pupa-forms of this insect. *Phial No.* 12 contains specimens of these.

34. The caterpillar is not unlike that of the *mamestra papaverorum*, and this especially in their younger stages, when both are of a pale olive-green. In the full grown form, the present species differs only in depth of shade from the younger form, acquiring a deep olive-green, with two lateral stripes of yellowish-green, and parallel lines of minute black spots, one on each segment. It forms a cocoon on the under surface of the leaf, and there passes into the pupa state. The pupa is of a shining chestnut-brown colour, with three black frontal spots and a line of smaller ones on each side: it is about ten lines long.

35. This caterpillar, though indifferently devouring the leaves, capsules and seeds of its ordinary host-plants of the pea tribe, in the case of the poppy appears to confine its depredations to the leaves, all the softer parts of which, however, it devours piecemeal. Like all the others, however, which have come under my observation, it does so only when the plant contains a very diffuse or diluted milk-sap. Then only, so far as I have observed, is it at all liable to the attacks of animal, and thus of course those which affect it in the maturing stage—as is the case with this and several preceding insects—cannot in any way affect the drug-produce of the plant, though they do materially diminish the seed-produce I can scarcely think that this view will be questioned by any one who has been at all observant of the poppy, and the particular stages at which it is liable to be attacked by insects. Such, anyhow, is my experience, and that the result of careful and extensive observations in the field.

36. In the earlier stages of the poppy plant, I have noticed a few foes of the grasshopper family. I have now to allude to another of its members as attacking the plant in its maturing stage. I may as well premise, however, that it really causes little or no injury to the plant, even as regards its seed-produce, far less that of its opium secretions. But that specimens of poppy apparently thus injured have been sent to me for examination from the Fategarh Sub-Agency, I had no intention of specially noticing them in this report. I also forward in two phials (Nos. 13 and 13*a*) specimens of the young and mature insects, with sections of the poppy stem, exhibiting the nature of their injuries. It is a species of the genus *Gryllus* the Titaiyah, or Tideryah, of the Hindustanees. It is in the younger stages only that this insect attacks the poppy, its depredations, moreover, being, as far as I can make out, wholly confined to the cuticle of the stem of the nearly mature plant. In phial *No.* 12, along with the young insects, I have enclosed small sections of stems thus injured. They carefully avoid stems, or portions of stems, containing milk-sap; and strangely enough the leaves are quite exempt from their attacks. As I have already remarked, they cause little or no injury to the plants, these being always in an advanced stage of maturity before they affect them. Heat, drought and scarcity of the usual food-stuffs has no doubt driven these young grasshoppers to the poppy-plant, which they do not naturally affect.

37. A small hemipterous insect has during the late season been very prevalent on all of the later poppy-crops. Like all the other members of this order, this does not gnaw or eat any part of its host-plant; but provided with a beak or rostrum, specially adapted for piercing and sucking, it attacks the leaves and all the softer parts and feeds on their juices. It is one of the many kinds of minute insects which the natives call *Lhi*. *Thrips* of the entomologist, and apparently *T. adonidum*. Its injuries to the plant, as I have explained in my Manual of Opium Husbandry, are due in the first instance to the withdrawal of the juices, which is alike the vital aliment of plant and parasite. Then, again, if the insects are carefully observed, they will be seen to void minute globules of a blackish liquid excrement. This rapidly concretes on the leaf, and thus, from the gregarious habits of this little creature, the whole surface soon becomes closely overlaid with their glutinous excrements, and so suppresses respiration that the whole leaf dries up and withers. To illustrate the character of their injuries, I have preserved, and forward herewith, portions of plant in an early stage of subjection to these parasites. I know of no practical mode of suppressing, or even mitigating, the attacks of these insects in the field. They are always abundant in hot and dry seasons, and, on the other hand, sensitive to and impatient of moisture; they are happily rare in wet seasons. It is well to observe, however, that even when most prevalent, they do not arrest, diminish, or deteriorate the opium secretions of the plant; inasmuch as it is only after the exhaustion of these, or their deposit in a fixed state on the walls of the vessels containing them, that this parasite affects the poppy. It imbibes and lives upon either the crude or elaborated forms of sap on which the plant itself lives and grows, not that special and protective secretion, the milk-sap or opium matrix. It does of course deteriorate the ultimate produce, and that seriously, when abounding as it did on last

season's maturing crop. Inimical as it thus is to seed-produce, however, it in no way impairs the returns of opium extract.

38. From the insects injurious to the poppy in the field, it may now be worth while to give brief notices of those which attack the seed in the granary and store-pot. In doing so, I must need pass beyond the domains of insects to the lower, but allied, class of *Arachuida*, that of *mites*, *scorpions* and *spiders*. Of this class we have two members of the *Acarinae* or mite family which affect the poppy—one in the *field* and *one* in the *granary*. In my Manual of Opium Husbandry, I have thus remarked on the habits and nature of injury caused by the field species, the scarlet mite or red spider, *Acarus telarius*, or more properly *Gamasus telarius*. As in the case of the *Thrips* species, this mite is most prevalent in hot and dry seasons. Its mode of attack is to envelope the leaves in a delicate, but closely woven web, which so checks the respiration that the leaves and ultimately the plant becomes dry and withered. It avoids the poppy in its milk-sap stage, and, like the *Thrips* species noticed above, it thus only diminishes the seed-produce of the poppy.

39. The other species of the above class, which attacks the seed in the granary, is a member of the allied family *Trombidina*, and, as far as I can make out, the genus *Tetranychus* probably a new species. In so far as I have observed, or can learn, it peculiarly affects the poppy-seed. With reference to this habit, and assuming it to be a new species, it can scarcely I think have a more appropriate name than *Tetranychus papaveræ*, the poppy-seed mite. It looks like a minute spider, being little more than a line in length, ovoidal, smooth and shining, and of a rich claret colour. Swarms of these mites may be frequently found in poppy-seed granaries and their store-pots. They then cause much injury to the seed, reducing not a small percentage to mere chaff and dust in their feeding operations, and moreover they occasion further damage by their glutinous excretions, which, in drying, glue the seeds together in more or less bulky pellets. Like other members of its family, it multiplies with great rapidity, and thus, though there may not be a single specimen visible in closing, all but hermetically, a store-pot of seeds in April, we find them in swarms, or again opening it in September. Their depredations or appearance in the store-pots may be effectively prevented by taking the precaution to sprinkle a small quantity of roughly pounded comphor amongst the seeds before closing the pot. For specimen *vide* No. 14 of the collection.

40. *Tipula*, the larvæ of a species apparently belonging to this genus, cause occasionally much damage to the poppy-seed in the granary and store-pots. I have described it in my Manual of Opium Husbandry. It has fortunately all but disappeared here since I began to use camphor in storing the seeds. So rare is it this season, that after much search, I have only succeeded in getting a very few specimens of the larvæ and pupæ: these are enclosed and forwarded in phial No. 15 of the set.

41. *Bruchus*, two species of this genus, attack the stored poppy-seed both in the larva and perfect state. That noticed in my Manual of Opium Husbandry is the more common of the two. This beetle is about four lines long: the body of a brownish colour, with the elytra or wing cases striated and of a dark amber-brown. The larvæ are short, stout and cylindrical, about two lines long, the head small, horny and furnished with sharp mandibles which enable it to penetrate readily the dry and hard seed. It is very destructive, rapidly shelling the seeds and causing further injury by the gluey nature of its excrements: these in drying draw the seeds together in pellets that are rapidly enveloped in the dense web of a pale rose-colored mould—the *Dactylium roseum*—which soon destroys their germinative power. Preserved specimens of the larvæ, and mature forms of this insect, are exhibited in phial No. 16 of the set accompanying this report.

42. A smaller-sized beetle, which I also refer to the genus *Bruchus*, is not unfrequent in the poppy-seed granary. It is rather more than two lines long, of an oblong shape, with a minute head of a horny texture, black and furnished with sharp mandibles: the wing cases are of a chestnut-brown colour. They penetrate with facility the poppy-seed, and leave it an empty husk. They are thus very destructive; but, as far as my observations go, less common than the preceding. I forward a few specimens of the perfect insect: *vide* phial No. 17.

43. *Sitona*, a species apparently belonging to this genus, largely affects the poppy-seeds, as it does also those of the *Indian-corn*, *millets*, *wheat*, *barley*, and *rice* in the granary. Thus impeculiar in its food-stuffs, it is one of the most destructive of the many kinds of insects which affect the granaries in this country. It is of a linear-oblong shape, about an eighth of an inch in length, and of a nearly uniform pale chestnut-brown colour. The perfect insect and larva forms are alike destructive. In phial No. 18 of the specimens accompanying this report the larva and perfect insect forms are shown.

44. *Calandra* species, a snout beetle, linear-oblong, of a dull brownish colour, with striated wing cases, and about two lines in length. I have failed in identifying the larva of this beetle. In its perfect form, however, it burrows into the seed of poppy, of Indian-corn, millets and other cereals, as also a few of the pulses, reducing all to empty husks. It is a very serious pest in the granaries of this country. I scarcely think it is distinct from *Calandra comuta*, the common maize weevil. Specimens of the perfect insect are shown in phial No. 19 of the accompanying set.

45. In phial No. 20, I have enclosed specimens of a grub which has been of late rather common in the poppy-seed granary here, though I have not found it in the store-pots, where the seeds are almost in an air-tight state. I have not as yet traced the metamorphoses of this species. It is from four to five lines in length, of a pale brownish colour, specially clothed with short appressed hairs; head horny and hairy; it has six minute pectoral, but no abdominal or anal feet. It is a great pest in the granary, where it attacks not only poppy-seed, but *musoors* and *muturs*, burrowing into them, consuming their contents, leaving only the husks, in which it is very likely it passes into the pupa state. The best means of keeping this weevil in check is to frequently turn over and air the seed heaps (the grub is impatient of light, always carrying on its operations in the interior); also to have all occasionally sifted, affected seed separated and destroyed, as well as any grubs that make their appearance. The phial containing specimens of these grubs is No. 20.

46. While some such means as the above must be adopted for the destruction of grain insects in the open granary, those which specially affect grains in close store-pots may be effectively subdued by sprinkling small pieces of camphor amongst the seeds in storing them. The noxious effects of camphor on these insects in their different stages may be readily shown by placing a few of them with a piece of camphor in a close-stoppered phial. All very soon die, and so it is in our poppy-seed store-pots, when these are fairly air-tight.

47. The scanty information I have had from the district officers of the two agencies, relating to the insect injurors of their crops, may be as well recorded before I proceed to consider generally the prevalence and the cause and nature of the injuries that the late poppy-crop has sustained from insect attacks. Well, I have had but one special communication on the subject, which is from Mr. Assistant Drummond, of the Monghyr Sub-Agency. This officer, in a demi-official letter dated the 8th of March, remarks that "it may be interesting to you to hear of what, in this district, is a novel and hitherto unknown source of harm to the drug collections now going on, and the fast maturing seeds; or rather, I should say, what the ryots consider a source of harm to collections. I am myself doubtful on the point, and their opinion may not be worth much, as the oldest ryots, or men of twenty and thirty years' service among our amlahs, remember no similar occurrence. It is that caterpillars, described by you under the head of *noctua sp.* 2, have in several places attacked the plant, but only, as far as I can make out, of the inferior and sickly kinds, eating up the leaves, stems, and seed contents of the capsules. *Healthy plants*, or those *yielding drug, seem to be carefully avoided till such time as they have attained maturity or ceased to yield drug.* Their lower leaves, however, have been attacked in some cases, and I find that some caterpillars I am keeping in a box will readily feed on fresh leaves broken from healthy plants, in all stages of growth, and *on fully matured capsules, but not on those in the drug-yielding stage.* Their ravages are worst in fields where patches have already been cleared by blight, gangrene, &c., in fact among plant that we don't call first class. *Plants attacked, that have,* NOT REACHED *the lancing stage when broken, or cut* turn out PERFECTLY DEVOID of MILK. This however, may not be due to their ravages, but to other causes, and if so, any loss of outturn cannot be ascribed to them. This is a point on which I should be very much obliged for your opinion.....and also, as to whether hurt to the foliage would more or less affect the secretion of the drug. Their advent was preceded by cloudy weather and unusual heat, ending in a light shower of rain, more or less general all over the district. Their attacks are, however, much more local. Do you think that the cause can be certain atmospheric conditions, acting on the internal economy of the plant, and predisposing it to their attacks?"

48. I have been much interested with Mr. Drummond's letter, and in the above quotations have underlined it in parts, to which I would specially invite attention, as affording quite an independent support to my own views and recorded explanation. Mr. Drummond expresses doubt as to the insect pest having in any way diminished drug-produce. He indeed states that caterpillars, from the poppy which he has in artificial keeping, *do feed* on fresh healthy plants. This is easily explained: he refers to "leaves broken from healthy plants." Now, as regards leaves, or portions of leaves detached from the stem, the milk-sap is *very rapidly* FIXED *on the walls of its containing vessels*, so that even leaves replete with milk-sap when plucked, are almost immediately liable to the attacks of those caterpillars which we find on the naturally drug-exhausted plant. Mr. Drummond speccially states that he finds they avoid leaves, thus replete with milk-sap, on the plant. Again, Mr. Drummond observes that even healthy, and I presume drug-yielding, plants have been in some instances attacked. This of course is simply due to the fact, as indeed, if I mistake not, I have previously explained that alike in plants artificially depleted of their milk-sap, and those under natural conditions, the depletion in the first instance is from below upwards, as it is again naturally the milk-sap in the leaves being fixed in its special vessels from below upwards. Thus, from the point of views which I have advanced, we need not be at all surprised with the fact of caterpillars feeding on the *lower leaves* of drug-yielding plants.

49. The Sub-Deputy Agent of Shahabad, Mr. Peppe, in a visit to the gardens here in March, casually remarked to me on the prevalence of insects on the crops in his district, and that in many instances they had scarcely left a fragment of foliage on the plants. I explained to him, from my own point of view, the probable cause of this insect infest, and the results thereof, which I in no way modify now, viz. that while the insects had doubtless more or

less seriously impaired the plant's fertility as regards mere seed-produce, they could not in any way have diminished the drug-produce, inasmuch as the secretionary processes of the latter must not only have been arrested, but any *free drug* exhausted from the particular parts which they affect: this we know is the leaves; and moreover, that in a drug-yielding plant, they are successively attacked from below upwards as already explained. In so far as my memory serves me, Mr. Peppe gave me no decided opinion on the above views, though I should indeed be surprised to hear that, after further special observations in the field, he does other than fully support them.

50. The Sub-Deputy Opium Agent of Fyzabad, with reference to a letter of mine, referring to the receipt of a small tin, quite empty (the insects originally enclosed having all escaped), explains that the tin-box was forwarded as received from his assistant, Mr. Carter, but that he will endeavour to forward another and more securely packed batch. On the 16th of April he advises me of their despatch, remarking that "the only ones which could be got at this late season of the year have been divided, and one parcel sent to the Agent, and the other to him." With exception of one pupa-form, the few others unfortunately were quite dead, and indeed dry, when they reached me. The pupa I kept with care for about a fortnight, when I observed mould appearing on its case, a clear indication of mortification within; I thus at once placed it with the other forms in spirits, and forward all herewith in phial No. 21 of the series. As far as I can make out, they represent in all three species, comprising, however, only fourteen specimens. The moth, the two pupa, and one of the caterpillars I am disposed to refer to my *mamestra papaverorum*, and of the remainder all in the caterpillar state nine, are evidently the *noctua sp.* (No. 8 of my set); while the tenth, though new to me on the poppy, I recognize as having been very common on the maturing flower-heads of the common *Koosum-carthamnus tinctorius*. With the exception of the pupæ and two or so of the caterpillars, all have been more or less injured, and reached me in quite a mummified state, so that I have had some little difficulty in separating and determining the species. Mr. Gennoe, the Sub-Deputy Agent, makes no remarks on the prevalence or extent of injury these insects have caused.

51. The Sub-Deputy Agent of Goruckpore, in forwarding to me for examination specimens of blighted poppy, also sent a parcel of plants with capsules injured by insects, but without separate specimens of these. As many of the capsules presented unusually large borings, I cut up and examined all, and succeeded in getting a few of the insects: all, however, dead. Of these I find a perfect moth with four pupæ of *mamestra papaverorum*, four caterpillars of *Bombyx sp.* (No. 11 of my set), and one apparently *noctua sp.* No. 8. Of these the *Bombyx sp.* (the Kala-jhanjhi of the natives, the most bulky and destructive of any species which I have yet seen affect the poppy) is no doubt the species which has cut out the large holes remarked on in the capsules. In many instances it has moreover consumed the whole of their contents, seeds and inner walls, leaving only a thin outer shell. I forward a few samples of capsules thus injured,—*vide* phial No. 23 of the accompanying set. The Sub-Deputy Agent does not say whether or not caterpillars were prevalent in his district; the Kala-jhanjhi, if so, must have caused sad havoc to the seed crop. The few specimens of the insects I found in the capsules are forwarded herewith,—*vide* phial No. 22.

52. Mr. Assistant Innes, of the Cawnpore sub-division, in a letter dated the 1st of May, observes that "in a number of instances the plant suffered from caterpillars, which made their appearance about the same time that the blight did. The caterpillars, as a rule, attacked the capsule of the plant." The plants sent were well developed, the capsules medium sized, but containing very few seeds, though each rarely presented more than a single boring, indicating its affection by insects. I cut up and examined many of the capsules; they contained no caterpillars, but I found a few pupæ forms, a species of weevil, a small dipterous insect, and a portion of a moth wing. I will notice these separately. Four of the pupæ seem to me to be identical with those of *mamestra papaverorum*, three other empty pupa-cases, with the portion of the wing, much resemble the *noctua sp.*, No. 8 of my list. These specimens are enclosed in phial No. 24 of my collection. The weevil referred to curiously enough is one of those which I have already noticed as affecting and injuring the poppy-seed in the store-pots. It is *Sitona sp.*, No. 18 of my list. The presence of this in the capsules received by me partly explains, irrespective of the caterpillars, the small quantity of good seeds they contain. The small dipterous insect is new to me: I found it in a capsule (in which the seeds had nearly all been destroyed) with two pupæ forms, probably of the same species. Phial No. 25 of my collection contains these specimens, the perfect form being pinned on a small piece of cork; the phial also contains pupæ and perfect forms of the weevil, *Sitona sp.*

53. In a letter dated the 9th of April, the Sub-Deputy Opium Agent of Lucknow, advising me of the despatch of "poppy plants destroyed by caterpillars," explains that "the destruction has occurred heavily, but luckily locally, in and about a large village called Summessee, in the Lucknow district, and appears gradually to lessen the further the cultivation is off."....He continues: "The caterpillar was seen creeping gradually up the stem and leaves of the poppy, finally reaching the petals and gaining an entrance into the interior..... Many poppy-heads were opened and the caterpillars in various stages of growth found, the younger of a greenish colour, the full grown of a brownish tint; only one caterpillar was found in each capsule..... On the appearance of the caterpillars the cultivators state

that they watered the plant with a view to drive them away, but were not successful... .. The plant attacked, as a general rule, stood but one lancing, and then failed to yield, a *second* lancing was rarely afforded, and the later plant being also attacked gave nothing. I would point out that *gram* and *urhur* have been also to a large extent destroyed by caterpillars."

54. The capsules of the sample bundle of plants sent are, with the exception of the few from Goruckpore, more seriously injured with caterpillars than any I have yet seen. They differ from the Goruckpore specimens in having much more numerous but rather smaller-sized perforations: indeed, as previously remarked, not a few of them look as if they had been subjected to a discharge of shot. They contain no seeds; these and even the large projecting placentæ (or seed-bearing processes) having been consumed by the caterpillars, all that remains being thin and largely perforated shells. The capsules before me are of those referred to by the Sub-Agent as having yielded little or no opium, and they have clearly been equally unproductive of seed. I examined carefully many of the capsules for insects, but could find none. From the Sub-Agent's description of the young and full grown caterpillars, however, I have no doubt that it has been the common species, *mamestra papaverorum*. As illustrating the injury they have effected, I forward herewith specimens of the capsules,—*vide* No. 26 of my collection.

55. *Bareilly.*—The Sub-Deputy Agent, in a letter dated the 8th April, in advising despatch of specimens illustrative of the form of blight which had affected the plant in that division, observes on, and sends specimens of, capsules injured by caterpillars eating into them. Again, in a subsequent letter (dated the 10th April) on blight, he casually observes: "I amongst others have noticed an unusual number of *moths* this year, they appeared early in March; this would account for the caterpillars being so very numerous The capsules sent to me varied much in size, and few bore more than one perforation. For all this, however, the seeds, as I found on opening them, had been nearly all consumed. I found no caterpillars, but in three instances dead pupæ; these are again of the common species, *mamestra papaverorum*. Mr. Pratt, as above, alludes to the abundance of moths in the beginning of March; the caterpillar infest of the poppy was no doubt a main source of these, and from the time of appearance of the moths, the capsule perforations, and pupæ found in them, I do not doubt that they were largely represented by the *mamestra papaverorum*.

56. Mr. Assistant Paterson, of the Sirsa sub-division, in forwarding specimens of blighted plant, thus observes on insect injuries in a letter dated the 13th of April: "In the parcel with the blighted plants will also be found specimens of poppy capsules damaged by caterpillars. It will be seen that *only one or two punctures on these yielded drug, the others being quite dry.*" The *underlinings* are mine, as supporting the views advanced on the protective nature of the milk-sap in the poppy, and consequently its exemption from insect foes when it is present in normal quantity and quality. These correlations have apparently been overlooked, or at least not specially remarked on by the majority of the officers who have sent me illustrations of insect injuries; but I feel none the less confident that they will be objected to by few, if any, on a careful retrospect from this point of view of their own observations in the field, that is, the particular conditions of the opium juices, their quantity and quality in the plant, when it is liable to, and exempt from, insect attacks. Referring to the above noted absence or paucity of opium juices in the plant, Mr. Paterson continues: "This evil was also very common this year. Caterpillars also attacked the *roots* of mature plants, but of the latter I have not been able to procure specimens at this late date."

57. The specimens sent me by Mr. Paterson have stout, well developed stems, but capsules under the medium size, and all bearing from two to three and more caterpillar perforations; the capsules were utterly void of seeds, all evidently having been consumed by the caterpillars. Of the latter, I found a single specimen only, but this had been attacked by small maggots and quite undeterminable. What did remain, however, exhibited in the head the hairy stigmata and colour some little resemblance to the Burobhooa, No 9 of my collection. Mr. Paterson also states that the roots of the mature poppy plant were attacked by caterpillars. This has not in any instance come under my observation, and he was unable, owing to the lateness of the season, to send me specimens. I rather think he mistakingly refers this to caterpillars; it is much more likely to have been the work of one or other of the cricket family, noticed in the first part of this report. I observe, however, on the specimens sent, that the cuticle of the stem has in several cases been largely grown. This has probably been the work of the young grasshoppers already noticed, *vide* paragraph 36, and of which specimens are exhibited in phial No. 13 of my collections.

58. *Mainpuri.*—Mr. Assistant Hastings, in a letter dated the 20th of April, advising despatch of "diseased plants from Mainpuri district," observes that "only small and backward plant appears to have been attacked by disease, the symptoms being a general withering and blackening of the entire plant. The assamees told me that watering only aggravated the evil, but I think as a rule that the intense heat and careless cultivation induced the disease." The specimens referred to reached me after I had submitted to you my general report on the nature and cause of the so-called blight, but as they (and others received, even so late as the 9th instant,) present no new features, there is no call for a supplementary report, and I only allude to them here now

from the large percentage of wilding plants in one of the Mainpuri bundles. With plant such as this prevalent in the district, the Assistant Sub-Agent may well attribute failure to "*careless cultivation.*" This bundle consisted of healthily matured plant, of a strawy-yellow colour, bearing capsules, under the medium size certainly, and yielding little or no opium. Now, on examining the bundle, I find that the specimens largely consist of the wilding poppy with *porous* capsules, which, as every one knows, is a miserably poor drug-yielder; even under the most favourable circumstances it will rarely afford more than two copious drug-yielding incisions. In the bundle referred to, I find, out of the 65 plants sent, no less than 43 are of this wilding variety, which of course is, judging by the sample, very little under three-fourths of the crop. Such negligent cultivation should be severely reprehended, as injuring surrounding crops: thus a large percentage of the seeds of this porous capsuled poppy are invariably left on the field, carried to and fro during the rains, perfectly retain their vitality, and germinate simultaneously with those of superior varieties which the careful cultivator may sow. Now, as the wilding and domesticated races are not easily distingushed in their earlier stages, little discrimination can be exercised in the thinning of the crop, and a large percentage of wilding plant may be thus introduced in spite of the most careful cultivation. I have thought it worth while to forward, with my insect collection, a few specimens of the porous capsules of this wilding variety from Mainpuri,—*vide* No. 28 of the accompanying collection. For the sake of comparison, I have also included a few capsules of the cultivated varieties which have *non-porous* capsules.

59. I have now completed as well as I could my little history of the kinds, habits, and economy of the various insects which have attacked the poppy plants in the gardens under my charge, and those of the assamees in the vicinage, to which I have added such information as has been afforded me by the district officers, and that directly obtained by examination of the specimens of plants communicated. Now, as we all know the poppy plant during the past season has been much infested with insects, and these not only its ordinary or habitual foes, but others which have not hitherto been observed to affect it, it now but remains for me to explain as well as I can the causes which may have thus generally favoured the development and increase of those insects which affect cultivated plants, and especially the greater liability of the poppy to their attacks, the nature of the injuries thereby sustained, and such remedial measures as are suggested by a study of the habits and economy of those insects. *First*, for the causes which have of late so largely promoted the multiplication of insects injurious to cultivated plants, more especially those noticed in the context as affecting the popyy, and of which, with a few exceptions, specimens are forwarded with this report. Now, it is to be observed that many of these insects pass one or more stages of their existence in the soil, and as we have good evidence that all are more or less impatient to excessive moisture, it is easy to see that dry and wet seasons, as conversely propitious and unpropitious to their reproduction and increase, will also be more or less strikingly characterised by ravage and immunity to our crops from insects. Weather is, I believe, a main, not the sole, factor which directs, modifies, and controls the multiplication of those insect pests which are the subject of this paper. There are indeed many other kinds of insects, for example locusts, chinch-bugs, wheat-flies, &c., which spring up periodically in innumerable hosts, appearing and disappearing in a most inscrutable way, destroying as the samiel, or the simoon, and like which we may neither say "whence they came nor whither they go." It is thus that they have ever been regarded as a God-sent scourge on kindred nature; "the army of the Almighty, strong to execute his word," even as writien in the pages of sacred history, and of which all have childhood remembrances in the plagues of lice, flies, and locusts in the house of Pharaoh and the land of Egypt; or again, in a less familiar, but striking, passage in the book of Joel *II*, *V*, 25 and 26—"and I will restore to you the years that the locust hath eaten the cankerworm and the caterpillar and the palmer-worm, my great army which I sent among you, and ye shall eat in plenty and be satisfied." For all such apparitional scourges the teleological explanation has still, in spite of the advance of natural science, its old negative value, and now, as in all past history, living nature is still subject to such kindred plagues, quite irrespective of weather or climatic conditions, or indeed any other known cause or causes.

60. Passing from these really unaccountable visitations of insect pests (of which fortunately the opium poppy and districts have been exempt), to those with which the poppy and other agricultural plants have been of late infested, I repeat that, besides *weather*, and its complement, *season*, there are a few other causes which not unimportantly affect their genesis and economy. I will briefly notice these, which indeed form but a single relational series from the plant—the animal and physical nature. Thus, in India, within perhaps the last quarter of a century, the area of agrarian lands has been I believe fully tripled. This has largely involved invasion on forest land and the consequent destruction of trees, which, as everybody now knows, materially affects climate: forests generate humidity, and history affords many instances of fertile regions having become arid and sterile by their destruction. There can I think be little question that the climate of India has been thus generally affected, though of course specially felt in continental India and the northern parts of the Peninsular region, as for example the central parts of the Deccan, and even parts of Mysore. Such seasonal, and indeed climatal, changes are generally favorable to the genesis of insects, and especially so to those which have been of late the agriculturist's pest.

61. Again, this conversion of the natural forest lands into agrarian not only directly favours the reproduction and increase of those destructive insects, but indirectly, inasmuch as woods, or the forest skirts, are the favorite haunts of insectivorous birds and various other animal foes. Then, again, agriculturists in India, as a rule, practise no regular rotation of crops. The same crops from year to year are repeated with little variation, and insect foes thus favoured, as being afforded *in situ* a more or less special food-stuff. Now, it is easy to see how largely the ordinary class of insect foes might be subdued by the judicious rotation of crops, especially those of the cold season. True, we have to contend with insects which in the prefect state have organs of flight, but it is only in the earlier, or larva stage, that they attack our crops, when their powers of locomotion are tardy, laborious and imperfect. Thus under regular and judicious rotations of poppy, cereals, pulses, tobacco, dhanja and other aromatic herbs of the order, &c., &c., during the cold weather, with similar alternate crops of pulses, with cereals and the like, during the rains, there can be little doubt that those insect pests would be greatly subdued. Converse modes of husbandry, repeating from season to season with little variation the same crops, must clearly favour the reproduction and increase of their more or less peculiar insect foes. This conjointly with the extensive destruction of forests as deteriorating climate, and limiting the diffusion of insectivorous animals—as well as weakening them numerically—are highly favourable to the reproduction and increase of the insect foes of cultivated plants. The result is that from year to year there appears to be a steady increase of these destructive insects, and thus it is that, in seasons so exceptionally favourable to the developement of insect life as the last, they spring up in such alarming numbers, and almost paralyse special branches of agriculture over large tracts of country. I will only add here that the only feasible and really practicable means of checking or mitigating this evil, is for our agriculturist to adopt regular and systematic rotation of crops, and above all to preserve and encourage insectivorous animals, especially birds. Thus only can we hope to check or subdue those destructive insects which, under the facilities now afforded them, may soon become the chronic scourge of agriculture on this continent.

62. The next subject to which I will direct attention is the greater liability of the opium poppy, during the late season, to the attacks of insects, than has been previously observed. As a plant largely exempt from insect foes, this has naturally surprised the more casual observers. I find it has been especially remarked by a few of the older, more observant and intelligent assamees, who were quite at a loss to explain and struck with the phenomena of insects—several moreover unfamiliar to them—greedily devouring the green, and, as they naturally assumed, '*kharwa*' leaves of the poppy. The explanation is of course simple; they possessed not their *kharwa* qualities, or rather lost them in the premature exhaustion of their milk-sap. I explained this; they were evidently convinced, as many of them to their loss knew that really healthy and vigorous plant while quite green suddenly ceased to yield, scarcely affording one-third of its normal drug-produce. All have been dismayed with the results, and I learn that very many of the assamees, as well as others, are disposed to attribute the failure to the unusual prevalence of insects on the plant. There can be no doubt, however, that these were but consequent on, and in no way accessary to, the diminished secretion and premature exhaustion of the opium juices.

63. In reports previously submitted (I refer to that on specimens of blighted plant from Chupra, No. 480, dated 1st March, also my general report on the blight in the Benares Agency, No. 500, dated the 22nd April) I have offered explanations for this decreased fertility of the plant in drug. Of course other explanations have doubtless been suggested by officers of the Opium Department, but of these I know nothing; and after careful reflection, I find no reason whatever to modify in any way the views I have recorded. I will therefore, but briefly, restate these here, only premising that they have a general reference to the whole area of opium culture in the Government agencies. This, I believe, I have correctly attributed to extremes in the weather characteristics of the late and preceding seasons; thus, that of 1876-77 was characterised by an excess of moisture, whereas that of 1877-78 tended to the opposite extreme, drought aggravated by westerly winds and high temperature. Now, for the few years which I have had to do with the opium poppy, I have been particularly attentive to the influence of weather on the quantity and quality of the drug-secretions. I have shown how the drug-exudations are affected by the degree of atmospheric pressure, that under low barometric conditions, especially when accompanied by easterly winds and slight differences in the dry and wet bulb thermometer, the exudations from the capsule are spare and of low or watery consistence; whereas with a high barometer and light westerly winds, we have copious drug-exudations of high consistence. These views, I am glad to say, are fully supported to my knowledge by at least one officer of the department, Mr. Peppe, the Sub-Deputy Agent of Shahabad, who informs me that he has of late particularly attended to these phenomenal relations of drug-exudation and atmospheric pressure, having provided himself with a good aneroid barometer, as the most easily portable in his tours.

64. Again, besides these direct effects of barometric pressure and humidity of atmosphere on the quantity and quality of the daily exudations from the capsule, we must regard the general characteristics of the season as even more importantly affecting the drug-produce of the plant, and that both as regards quantity and quality. A normal fall of rain in the monsoon, followed by occasional light showers in November and December, or indeed until the appearance of the flower-bud on the poppy, with rather dry hygrometric indications, a

clear atmosphere and light westerly winds, are the conditions most favourable to drug-secretion and exudation. On the contrary, moist or wet seasons, while promoting the vigour of the plant, tend to arrest the secretion of the milk-sap, or, as I should rather say, its due elaboration. This is of course more especially the case when such conditions obtain during the maturation of the plant's juices, that is, on its approaching the flowering stage, and onwards. Occasional rainfall, with low average hygrometric indications during this stage, impede the maturation of the milk-sap, and the drug-exudations are then invariably of low consistence, more or less abounding in watery matters and *pussewah*, that is, crude or unelaborated opium juices, with difficulty separable from the normal drug, and generally deteriorating it in its physical properties *colour, aroma, and texture.*

65. I have treated of the effects of weather at particular stages of the plant's growth, as also of season generally; and now I have to direct attention to the effects of humidity of season or climate, as materially affecting the seed, in so far as regards the opium produce of the immediate crop. Seeds grown and matured in wet seasons are thus, as I believe, but ill suited for an opium-producing crop in a dry season. The results, strangely enough, are very similar to those obtained by the introduction and use of seeds from a moist to a dry climate. For example, seeds of the opium poppy grown in Lower Bengal yield a very scanty opium-yielding plant in ordinary seasons in Behar. Thus again it was that the experiments with Malwah seed in the two agencies failed so signally; whereas in the converse case, that is, cropping in Malwah with Behar and Benares seed, they were fairly successful, the Malwah climate even during the hot season being mild and moist, which explains the comparative success of the Behar seeds. Again, in my experiments with seeds directly imported from Italy, Turkey, and Spain (in all of which countries the poppy is a *summer crop*), I found that the plant was remarkably vigorous, and gave very fair average returns of opium from the first season's crop; certainly superior to Malwah, even after it had been cultivated for several seasons in this country. It is on these grounds that I have urged a system of introducing seeds from *drier* to *wetter localities*, from light sandy soils to the heavier and moist clays, and the avoidance of converse changes. Punjab grown seeds, for example, would, I feel convinced, have afforded us last season a superior opium-yielding plant to that of local origin. It would have been of special advantage to those who will persist in late cropping, nearly all of which has so signally failed this season from the prevailing heat and drought, as having succeeded one of maximum moisture—that of 1876-77; this again having been preceded by one of full average humidity, and that not only in Behar but over the whole area of poppy cultivation. Thus, in the report of the Punjab Irrigation Department for that year, in referring to a decrease of more than 200,000 acres in the area of irrigation, it is explained that "this unfavourable result is chiefly due to the heavy rainfall, which enabled the cultivators to dispense with irrigation for their cold weather crops."

66. Now, as I believe, in the above indicated seasonal variations we have the true explanation of the scanty opium produce of the late crop, the late season (1877-78) being unusually dry, with a high average temperature, and preceded by two seasons of maximum and average humidity. Such differences in season, then, as I have already explained, are unfavourable to opium produce. This indeed is, to the misfortune of all concerned, too forcibly illustrated by the results or returns of drug from *early* and *late* crops, the former, even as regards the plant under my own charge, yielding from *four* to *five* times more drug than the latter; and it should be observed that my latest crops had germinated by about the third week of November. Now, I learn from reports sent me that in not a few instances sowing was continued to the first week in December. These seem to have altogether failed. Last season's experience shows that the very *earliest plant* only afforded little more than the annual average return of drug. Later crops, on the other hand, under increase of heat and drought, graded off from a *minimum average to nothing.*

67. With these explanations then I will now return to the question of the greater liability of the plant during the late season to insect foes. This, as already explained, was, I believe, due to a paucity of milk-sap in the plant and its premature exhaustion by the ordinary processes of artificial extraction. Field observations in this district, and an examination of plants sent me from, I believe, all the sub-agencies under the Benares Agent, only too clearly evince the paucity of drug. Thus, even in large, normally-formed capsules, I find that a second scarification in many cases has quite exhausted the drug-secretions: normally they should have afforded copious exudations to, say, five or six incisions. Many, very many, other bundles of specimens were sent me consisting of the later plant, which had yielded no opium; the matter exuded from the scarifications having been evidently of a watery consistence, and simply dripped from the capsule.

68. Now, as there can be no question as to the general paucity—indeed, as regards the later crops, absolute poverty—of the opium juices in the late poppy crop, and believing, as I do, that these juices in no way contribute to the vegetative or reproductive systems, but on the other hand have a *special protective function*, as originally suggested to me by Mr. Darwin, we have the true explanation for the greater liability of the late crop to insect pests. As further supporting these views as to the protective nature of the opium juices in the economy of the plant, I will record the result of a direct and very conclusive experiment. It is this: for the past five years I have regularly devoted one small plot of land in the gardens under my charge to the cultivation of poppy plant from which I extracted no opium. This of

course was with a view, from season to season, of proving whether the seed-produce of such plants did or did not give rise to a superior-opium producing progeny. The general result of these experiments show clearly enough a falling off in the opium produce of the plant, but the experiments during the past season have none the less afforded me excellent illustrations of the protective nature of the opium juices. Thus, of the crop raised from the '*untapped*' capsule-seed, I of course always extract the drug from about half of the plant. Now, as regards our present point of view, the results are most instructive, indeed, as I think, conclusive. Thus, on a small plot of land we have a crop of poppy, one portion of which has the milk-sap or opium juices extracted as usual, while in the case of the other these juices are naturally fixed in the plant. I particularly invite attention to the results. Thus, while that portion of the plant maturing with its natural secretions of milk-sap obtained an immunity from insects, the other portion—observe a continuous plot—was much injured, producing about a half less in seed. There can thus, I think, be no question that the different results are wholly attributable to the presence and absence of the opium juices. These results, as they appear to me, are very conclusive, and I shall indeed be greatly surprised if the officers of the department generally do not agree with me in an unbiassed retrospect of their own observations of insect injuries in the field. Anyhow, I can arrive at no other conclusion, after a very careful observation of the plant in the field and examination of specimens communicated to me from the several divisions of the Benares Agency. As regards the Behar Agency, with a single exception, Chupra, no specimens have been sent to me. It may be, therefore, that the latter agency has had less cause to complain of failing crops, though, so far as I have observed, and been able to acertain of the prevailing weather, I should be surprised to hear that the opium produce exceeds, if at all, *a very low* average minimum. I refer to this simply in connection with my own experimental results and field observations in this district, with reference to the reports and specimens sent me for examination from many districts of the Benares Agency, which show that all have been very similarly affected, as also more than ordinarily subject to insect pests, and affording but a moiety of drug.

69. I will now more particularly notice the nature of the injuries sustained by the poppy plant from insect attacks. It seems to be a prevalent, certainly mistaken, notion that insects are largely accountable for the impoverished drug-secretions of the late poppy crop. This I have already explained; and I will only observe here that, after careful and somewhat extensive observations on the opium poppy in the field, I know of no insect which will attack the plant or any part of it when anyway replete with the normal milk-sap. It is a most efficient protection to the plant from an early stage of growth to its later stages of maturation. In the germinating stage, and indeed during the development of the root-leaf system, the plant, as we have shown, is liable to serious injury from insects, the milk-sap being then bland and innocuous. It would thus greatly advantage the poppy if the normal milk-sap was fixed in the seed and secreted by the germinating plant, the seed and the young plant being alike subject to injury and destruction by insects. Now, I have shown in the preceding paragraph that, in the later stages, when the plant is allowed to mature with the milk-sap or opium juices, it is scarcely at all affected by insects, or, if so, only when these become fixed in the capsule at a late stage of maturation. Insects then do perforate the latter and devour the seeds. We thus see that in the seed and the plantlet the protective principles fail, though nevertheless perfectly efficient in the other stages of the plant's development. Thus, even in the poppy we find, as remarked to me by Mr. Darwin, that *no defence is really perfect.*

70. First, as regards those insects which attack the plant in its younger stages. These, as all know, destroy the whole plant, and when abundant, as in the late season, may utterly ravage the young crop over large areas. These are the insects which the opium cultivator has to dread and avoid. This may be done, and, as I believe, effectively, by the simple precaution of sowing early. In so far as my observations extend, these insects rarely appear any way numerously before the middle of December. The *kumwah*, *Noctua sp.*, indeed appear earlier; but this may be subdued by copious irrigation of the young plant (which brings them to the surface and exposes them to their natural foes, crows and mynas), or what is equally effective and more generally practicable or operative, from the frequent absence or scarcity of these and all insectivorous birds in some districts, is to sprinkle the plants and the surface of the soil with quicklime. If not very numerous, a mixture of this in about equal parts with ashes will generally suppress them. These top-dressings should be applied in the evening, as this caterpillar, unless in cloudy and moist weather, is not a day-feeder; and thus such applications made during the earlier part of the day are considerably less active when it appears to commence its depredations.

71. The other insects which attack the young poppy rarely appear, as above observed, before the middle of December, and thus when the early sown plant has attained a stage when it is largely exempt from their attacks. The late sown plant (that germinating towards the end of November and in December) is really alone subject to their ravages. In the case of the late crop, these appear to have been very extensive; they were at least so in the limited range of my observations, and I heard frequent reports of their depredations elsewhere. Plainly then, to avoid at all successfully these enemies, *early cropping must be adopted.* To this practice I have observed it is very generally urged that, unless in very cool seasons, the young plant

is apt to be destroyed from heat and exposure to sun. There can be no question as to this, when the usual mode of *plane surface* cultivation in koeries is adopted. The drill or ridge system, however, as I have for long urged, perfectly meets this evil: the cool and shade afforded by these little ridges is all that is required to enable the plantlets to establish themselves, when others exposed to the sun, on the plane surface of the koeries, are being simply burnt up. I need not dwell on this further, however, as I have so repeatedly pointed out the advantages of the system; and as regards that specially under notice, the protection of the young crop from insect foes, I can really suggest nothing more simple, practicable, and effective. I do not despair of the assamees ultimately adopting the drill mode of culture, particularly for early cropping, as also the selection of seed, involving, as they do, manifest advantages to all concerned—individually, socially, and fiscally—in securing early crops, in increasing absolutely the fertility of the plant, and thus permitting of reduction in the area of opium cultivation, and consequently the extension of other agricultural products.

72. I pass on to consider the nature of the injuries which the maturing plant is liable to from the attacks of insects. These, as I have already stated, only affect the *seed-produce* of the plant. I repeat, after careful and extensive observation, that the parts of the poppy plant, so long as they contain the milk-sap in a normal state of concentration and diffusion, are quite exempt from insect attack, as they are also from all vegetivorous animals. On the late crop they were indeed observed to largely attack the plant while all its parts were green and the seeds far from mature; moreover, that caterpillars not hitherto observed to affect it were also prevalent. All is of easy explanations. As every one practically concerned or interested in opium culture knows, the drug-exudations of the late crop were abnormally scant. That in fact the plant, while green in all its parts, and to all appearance perfectly healthy (even before the capsules had attained their full size, with seeds in an early embryonic stage), had its drug-secretions exhausted by a first or second scarification. This appears to have been generally remarked, though, strangely enough, with a single exception, as alluded to in a preceding paragraph, quite irrelatively to the paucity or absence of the opium juices. I refer to the communication of Mr. Assistant Drummond, of the Monghyr sub-agency. As already explained, however, the plant is not subject, or in any way liable, to insect attacks from the earlier periods of the secretion of the opium juices until they are either artificially exhausted or naturally fixed in the mature plant. In either case the seed-produce is alone affected, and this, I may add, much more in the case of the former than the latter plant; I refer to the results of my experiments with plant which had none of its opium juices artificially extracted. The cause of the generally impoverished drug-secretions I have attributed, I believe correctly, to weather differences in the late and the two preceding opium seasons of 1875-76 and 1876-77, both of which were more than usually humid, the latter markedly so, whereas the late season presented an opposite extreme in heat and drought. Now, the drug-secreting function, as we all know, is peculiarly sensitive to weather; a clear and dry atmosphere promoting, a cloudy and humid atmosphere diminishing, secretions. Again, a dry and hot opium season succeeding a cool and wet season is unfavorable, even as we find it to be in introducing poppy seeds from a moist to a dry climate. On these grounds I have explained the impoverished secretions of the late season's crop. This also explains the greater liability of the plant to insects; inasmuch as apparently perfectly healthy and well-developed plants had their drug exhausted by one or two scarifications, while in many instances the very late plant seemed to be almost void of milk-sap, or contained it in such a dilute or watery form that on scarification of the capsules it dripped off, leaving little or no residue. In this, then, as I believe, we have the explanation of the greater liability of the plant to insect attacks, the premature exhaustion of the milk-sap in the advanced or earlier crops. The season again, as I have attempted to show, was unusually favourable to insect multiplication and, on the other hand, unfavourable to vegetation; hence it need be no matter for surprise that the poppy plant, *awanting in its protective principle*, became the host-plant of a numerous train of insects.

73. It would thus appear that the opium poppy is not at all liable to the attack of insects when replete with its normal milk-sap; its stages of liability being, first, of the plantlet prior to the commencement of the normal secretions, and again in the maturing stage, when these have been artificially exhausted: the untapped capsule plants having, as I have shown, considerable if not complete immunity. Thus, as the milk-sap is withdrawn from the lower leaves upwards, the lower leaves may and generally are void of milk-sap. A few days before the capsule has been depleted do they become subject to insect invasion. In ordinary seasons the *mamestra papaverorum* is about the only species affecting it. During the late season, however, a host of others, more or less peculiar to *pulses*, *mustard*, and others of these tribes, appeared on the poppy, driven no doubt to it by the scarcity of their usual foodstuff and inordinate individual increase. The poppy thus everywhere more or less in proximity to the pulse and mustard plants, itself presenting a copious and green foliage of comparatively bland quality (or at least but slightly tinctured with its bitter and nauseous milk-sap), the explanation of its invasion by caterpillars is clear; feeding, as they all apparently do, indifferently on plants with such very dissimilar qualities as the pulse and mustard tribes, instinct failed not in guiding them to the poppy with foliage scarcely more

pungent than one of their ordinary foodstuffs, the *mustards*, and any how differing less in properties than those do from the pulse tribe. Thus, with an inordinate abundance of these caterpillars, a failing supply of their more special foodstuffs in proximity to the poppy, with its copious foliage and modified properties, we have, as it appears to me, a satisfactory explanation of its greater liability to insects.

74. There can, I think, be no question that these insects do not in any way affect the drug-secretions of the opium poppy, inasmuch as their advent is not only consequent on the completion of the secretive processes, but even that of their exhaustion or fixation in the plant. Their injuries, however, are none the less serious, first, in denuding the plant of leaves (which have a certain value to the assamees from their extensive use in the godowns as a packing material for the China opium). and again as penetrating the capsule and consuming the seed. Especially destructive to the seed is the *mamestra papaverorum*; it early passes from the leaves to the capsule, and I have not unfrequently observed instances of its penetrating the capsule before the drug had been quite exhausted. In such cases, however, we invariably find that it makes its entry by an *old* and *dry patch, or scarification, never* by the *uninjured, juice-containing tissue.* I particularly invite attention to this, as casual observers are very apt to, and as I know do, form mistaken conclusions from the presence of caterpillars in a drug-yielding capsule. In these cases the caterpillar is most destructive, the soft, bland, and immature seeds forming an easily masticable foodstuff and thus largely devoured. On the other hand, as far as my observations go, I find that the casual insect visitors mainly confine their depredations to the foliage. In a very few instances have I found them penetrating the capsule and devouring the seeds. I had one instance of this in capsules sent me from Gorakhpore, as already noticed, and the destructive nature of which is exhibited by the specimens forwarded under No. 23 of my collection. Thus, as I have previously remarked, it would evidently greatly advantage the poppy if the secretion of the opium juice was performed by the seeds. But here again we have an illustration of a remark to me by Mr. Darwin, that he did "*not believe that any defence was perfect.*" Indeed, that it should not be so is a necessity of existing organic nature, as "parts of one great whole" of mystical origination indeed, but progressively evolved or developed (phyllogenically or in lines of descent from the low and simple to the high and complex), in manifold form, by natural selection, or the survival of the fittest, which involves correlational variations in structure, habits and economy, one with another, and with all others in an infinite complication of lines, defensive and offensive. Organic nature as a whole or complete factor, directly or indirectly, thus involves under its present constitution a really universal parasitism. It may well be therefore that no defence is perfect. Physical force, as geology teaches us, in its own peculiar history, was alone wont to disturb the progressively complicating balance of organic nature; but since man's advent, or rather in the progress of his civilization, we have another and more serious disturbing agent, as is generally shown by recent organic geography, and especially as correlated with or affected by domesticated animals and cultivated plants. Practically then, and with reference to this system of defence which obtains in nature under this head, I conclude with the remark that, in so far as relates to the secretion and exudation of drug by the opium poppy, there is no cause of alarm from the attacks of insects.

75. In connection with the diminished drug-secretions of the late poppy crop, and its greater liability to insect attacks, it is interesting to note that within my experience I have never found it so slightly affected with its hereditary mould – *Peronospora arborescens.* Indeed, the later crops seemed generally to be quite exempt: all their parts in maturing assuming a uniform strawy-yellow color, and presenting none of those brownish discolorations which so readily betray its presence either in the vegetative or fertile form. I allude to this here with reference to, and as apparently supporting, the views advanced in previous reports on certain variations in the quality of the poppy sap as affecting the development of this mould. It is a true parasite, with its mycelial or root-processes fixed in the inner tissues, and supporting itself wholly from the sap of its host. It is, moreover, so far as known, almost peculiar to the poppy species. It is thus, as it appears to me, not at all improbable that this comparative immunity to mould may be due to certain alterations in the plant's juices unfavourable to the mould's growth, and of which we have evidence in the greater liability of the plant to insect depredations.

76. With reference to the Board's orders forwarded with your memorandum No. 13 of the 13th ultimo, to procure and submit specimens of the various insects which have injured the late poppy and rubbee crops, I regret that they reached me too late in the season to enable me to illustrate so fully as I should have liked the enemies of the latter crops. The *poppy series*, in so far as regards this district, will, I believe, be found fairly complete. I annex a short account of the species which have affected the rubbee crops, accompanying them with specimens of the majority preserved in spirits.

77. First, of the *wheat, barley, and millets.* In the early stage I observed in this neighbourhood that cereals suffered more or less from the larvæ of one of the click beetles commonly known as wireworms), the *elaters* of the entomologist. These larvæ attack the underground parts of the young plant-roots and stalk, and thus, where at all prevalent, cause much injury. So far as my observations go, the wheat and barley crops, where freely mixed with *sursha* and *rai,* suffered less than others. In Europe and America it is well

known that *white mustard* (*sinapis alba*) effectively subdues *wireworms*; and considering that our sursha and rais are all closely allied species, it is not improbable that they may be equally obnoxious in this country to this destructive tribe of insects. The intermixture of these mustards with the common cereals, as practised by the native agriculturists, is thus highly recommendable as no doubt tending to subdue wireworm depredations. These insects, however, appear to have been local, and really caused no extensive injury to the later cereal crops.

78. The latter, however, have suffered, and that very generally, as it appears, from an *orange-coloured rust*, a parasitic fungus of the genus *Trichobasis*, the *hurdah* of the Hindustanees; *barley* and *wheat* more especially. In the earlier stages of development we find it breaking out in short, isolated, and linear patches, which gradually become confluent, and ultimately cover the upper surface of the leaves and their sheaths with a dense orange-yellow powdery matter. This *rust* has seriously injured the above crops in this district. The millets have been in this district comparatively free of parasitic fungi and insects. In the maturer stage, indeed, some little injury was caused by two grain-feeding insects. These are identical with species which consume poppy seeds, species of the genera *Citona* and *Calandra*, specimens of which are forwarded in phials Nos. 18 and 19 of my collection. From a short notice in one of the daily newspapers I observe that *cholum*, one of the millets (*Sorghum nulgare*), has apparently suffered in the Madras Presidency from *smut* and *insects*. Dr. D. Cunningham, on special duty, attached to the Sanitary Commission under the Government of India, and to whom specimens had been forwarded for examination, observes that "the specimens consisted (1) of heads affected by a species of *Ustilago*; (2) of heads which had been attacked by insects and secondarily by the conidial form of some Pyrenornycite..... The grains which had been attacked by insects were eaten across, and the exposed section was blackened by the filaments and conidia of the secondary mould. The blackening was quite superficial, and this, together with the nature of the fungus, clearly showed that the fungal development in this case was a consequence, not a cause, of the injury to the grain." The above grain, in this district, as indeed all the *millets*, have been singularly free from *smut*, as has also the common Dhoob grass (*Cynodon dactylon*); whereas in the preceding cold season (1876-77) all were more or less seriously injured by species of *Ustilago*, as must have been observed by even the most casual observer from the frequency of smut-coloured ears. This was very markedly the case with the Dhoob grass.

79. Following the natural sequence, I will now invite attention to the following members of the *Solanaceæ*, or nightshade family,—the potatoe, the brinjals, and tobacco, with the thorn and egg apples, and the henbane plant. The early potatoes, raised as they all are from local grown sets, were extremely poor, alike in size, in number, and actual weight of outturn—the latter is said to be from ten to twelve maunds per beegha only for the late season; whereas last year the outturn was from *eighteen* to *twenty maunds and upwards*. Later crops from Darjeeling and Cawnpore sets have afforded better outturns, though also inferior to the previous seasons. The earlier, and even later crops, were injured by at least two species of insects. Neither fortunately were general, so far as I have been able to ascertain, in this district. One is a species of the genus *Noctua*, and the same as that which I have noticed as attacking and cutting over the young poppy plants. It is of course also in the caterpillar stage that it attacks the potatoe, affecting the young sprouts or shoots, and cropping them over as they appear above the surface of the soil, as also underground. It also extends its attacks to the more advanced shoots, boring into them under the surface of the soil and consuming the soft interior parts, so that the whole shoot soon droops, withers, and dies. The other insect foe of the potatoe is the larva of a species of *wireworm* or skip-beetle (*elater*), but distinct from that which I have noticed as attacking our cereals. It penetrates the tubers and feeds on the inner part, thus causing much injury to the crop when at all abundant. It is not improbable that one or other of these is that referred to by the Member in charge as having attacked the potatoe in the jail garden at Arrah. In the instances which came under my observation, I should state that the wireworm mainly attacked the original sets, and thus occasioned less injury than if wholly directed to the young offsets.

80. The brinjal (*Solanum melongena*), the tomato (*Lycoperiecum esculentum*), and even the common thorn apple (*Datura stramonium*), were largely infested with insects this season. In each case the fruit only was attacked and all the soft cellular parts surrounding the seeds consumed. It is mainly caused by the maggot of a small beetle which I cannot determine. I send specimens, however, of the larvæ and perfect insects. In some of the partially mature fruits which I cut up of the above plants I found swarms of these maggots. The specimens are enclosed in phial No. 29 of my collection. It is interesting to observe, with reference to the general economy of the special secretions of plants (which I have attempted to illustrate in the case of the poppy), that *tobacco* and *henbane*, well known as combining narcotic, exciting and poisonous properties, with a heavy, obnoxious smell, were quite exempt from insect or other animal foes. Both, however, were more or less seriously affected with an orange-brown coloured rust, probably of the genus *Trichobasis*. The roots of the former were moreover very seriously infested in some localities with two of the broomrapes, *Orobanche indica* and *Orobanche cernua*: the latter is, however, by far the more common on tobacco, the former on poppy. Thus, though both are really highly exempt from animal foes, they are more or less subjeet to affection and injury by parasites of their own kingdom.

81. I pass on to the *Composite order*, one of the most numerously represented, as it is perhaps the most natural, or easily recognised, while possessing the most varied properties of any in the vegetable kingdom. A more or less pronounced bitter principle indeed pervades the order, but this is accompanied with various aromatic, tonic. and stimulant qualities, to which in one of the sections, or sub-orders, with a special milk-sap, we have more or less active, narcotic secretions. I will notice the following as comprising the more important of those cultivated in the field and the garden in this country :—

Guizotia abyssinica, "ram-teel."
Carttamnus tinctorius, "kossoom."
Cynara scolymus, "artichoke."
Tragopogan porrifolius, "salsify."
Scorzonera hispanica, "Spanish salsify."
Lactuca sativa, "lettuce."

The two first-named are two well-known agricultural plants, both valued for their oil-yielding seeds, but the latter specially as a dye-plant—the *safflower of commerce*. The *ram-teel* appears to be very little cultivated in this district, and I only allude to it here as having found the few plants I had affected and injured with the same kinds of insects as those I found on the *safflower*. In both the flower-heads were attacked by various larvæ—coleopterous, lepidopterous, and dipterous. The ova are apparently deposited in the flower-heads, so frequently do we find larvæ in their earliest stages of development within them, while none can be found on the stem or leaves. They feed upon the young seed and receptacle. The large larvæ, of which specimens in various stages are exhibited in phial No. 30 of my collection, leave the flower-heads before they are full-grown, and find their way to the soil, which they penetrate, and apparently feed on the roots of the plant until they pass in to the pupa state: this also being passed in the soil. In the few specimens which I had, I did not succeed in rearing the perfect insect; all died in the chrysalis state. One of these is included in the above phial. It is probably lepidopterous. The various other species exhibited in phial No. 31 of the illustrations are apparently hatched and matured within the flower-heads. So far as I can learn, none of these insects have been hitherto observed to affect the *safflower plant*. They appear to have done considerable local injury to the later crops. These, the late crops of safflower, were also largely infested by a species of *aphis*. In many instances it quite overran the plant, covering alike stalks, leaves and flowers. Specimens of this aphis are exhibited in phial No. 32 of accompanying set.

82. The few other members of the composites which I have now to notice are all members of the vegetable garden. First, of the *artichoke*, which may be so successfully cultivated in this district. I had here a good few plants of the conical or French and the large globe varieties. I was surprised to observe that, while the latter was all but exempt from insects, the former was very much injured by them: this was mainly caused by a species of *cassida*. Indeed, in many cases the leaves were reduced to mere skeletons. Moreover, the younger leaves and shoots of this variety were also infested with an aphis, which scarcely at all affected the globe variety. I have been much struck with this, as, with the exception of the straight and incurved involucral scales, they present really no other appreciable distinctions. The *cassida* and *aphis* species, however, are more discerning, as shown in their confining their depredations to a single variety in a mixed group. The grub of the former so much resembled that of the *cassida viridis* (which is found on the artichoke in Europe), that I did not collect any of them for rearing artificially. Later, early in April, in looking over the plants, I found that they had completed their metamorphoses and disappeared. After much search I found but a single specimen of the perfect insect. It is clearly one of the *tortoise beetles* (cassida), but distinct from *cassida viridis*. This specimen is No. 33 of my collection. I may observe that the tubers of the few plants in the gardens here of the Jerusalem artichoke (*helianthus tuberosus*) were also much injured with wireworms. I have not on any previous occasion found them affecting this plant. Of other allied esculent rooted plants, I was surprised to find that *salsify* and *scorzonera* were also more or less injured with wireworms. On the other hand, the common *succory plant* (*cichorium intybus*) was quite exempt from insects, alike in the roots, leaves, and flower-heads. Early lettuce, not only in the seed-bed but after transplantation, suffered much from the attacks of wireworms, which gnawed the stem under the surface of the soil. Later crops were, moreover, much affected with *thrips* and red-spider. In dry seasons these *thrips* and *mites* are the pests of vegetation, generally affecting indifferently plants of the most varied properties. They are fortunately kept in check by temperature, appearing only towards the close of the cold season; they are again checked and soon disappear when the hot weather fairly sets in. They are thus as effectively controlled by a medium range of temperature as the degree of humidity.

83. On the assumed protective nature of the secretions of plants generally, it is interesting to observe that various umbellifers, cultivated more or less extensively in this country for their aromatic properties (which is due to the presence of a volatile oil), had a complete exemption from insects of all kinds. I allude to the following:—

Petroselinum sativum, common parsley.
Ptychotis ajowan, boro-jhoan or agwaun.

Fæniculum vulgare, common fennel.
——— *panmori*, pan-meshoree.
Anethum sowa, soolpha or souph.
Coriandrum sativum, dhunya.

It appears to me very probable that their exemption from insect foes may be due largely if not wholly to the aromatic secretions. This is supported by the fact that the *unblanched* parts of the common garden celery are not subject to insects; whereas the *blanched* parts, as void of their normal secretions, are greedily devoured by various larvæ.

84. The cucumber family deserves a passing notice. Various members of this family are more or less extensively cultivated all over India, and indeed form a not unimportant auxiliary in the native foodstuffs. Those generally cultivated are the following:—

1.—*Vegetable class.*

1. *Momordica charantia*, two varieties, khuroola and oochhia.
2. *Luffa fœdita*, jhinga or torooi.
3. *Benincasa cerifera*, koomra, or chal koomra.
4. *Lagenaria vulgaris*, kudoo.
5. *Cucurbita maxima*, suphuree-koomra.
6. *Cucumis sativus*, two varieties, keera and balun keera.
7. *Trichosanthus anguina*, cheechinga.
8. ——— *dicœca*, pulwal.

2.—*Fruit class.*

9. *Citrullus cucurbita*, turbooza or turmuz.
10. *Cucumis momordica*, phoot or phooutee.

85. The above have been all more or less infested with insects this season. It may be worth notice however, that none of the lepidoptera affect them; their foes being chiefly coleopterous, with occasional orthoptera, crickets and grasshoppers, and hemiptera, bugs and aphis. Of the first class, in the earlier stages of growth Nos. 3, 4, 5, and 6 were much injured by a small beetle, of which specimens are enclosed in phial No. 34. This is an annual pest of certain members of the cucumber family throughout Bengal and the North-West Provinces. It attacks the leaves and young shoots, and abounding, as it did, in this district last season, it caused great injury, indeed destroyed much of the earlier plant. Alike in the larvæ and perfect state, they are a most serious pest to the cultivator of the above species. Again, in the more advanced stage, all (including the above vegetable and fruit-bearing sorts) have been infested with an allied beetle, which feeds on the younger leaves, the flower-buds, and the inner parts of the expanded flower; thus causing much injury to the crop. Specimens of this beetle are exhibited under No. 35 of my collection, along with which I have included a portion of a leaf as illustrating their destructive operations. Phial No. 36 contains specimens of four species of bug more or less common in the plants during their flowering period. Again, in phial No. 37 will be found four species of beetles, of which one, the *snout-beetle*, feeds on the flowers and their parts, while in the case of the others the larvæ consume the leaves and young shoots.

86. The lady-bird, or lady-cow (*coccinella* of the entomologist), are generally accorded a place amongst the plant's welcome visitors; inasmuch as in the larvæ and mature stages they are said to feed *exclusively* on its injurious parasites, the *aphides*, or plant-lice. This may, indeed I know is, the case with some of the species, but certainly not with all. It is at least so with one now before me, a *twelve-spotted* lady-bird, which alike in the grub and perfect state feeds on the leaves and flower-buds of nearly all the members of the cucumber family above enumerated. They thus cause much injury to the plants, and this when there is no scarcity of aphides upon it. I forward specimens of the insect in its different stages, together with leaves destroyed by them. These are included in phials Nos. 38 and 39. Again, in phial No. 40 are specimens of an *aphis* abounding with them on the plants so seriously injured. The lady-bird species thus comprise not only welcome but very unwelcome visitors to their host-plants. Very lately, that is, since about the middle of this month, the larvæ apparently of a beetle has made its appearance. It attacks the lower surface of the young leaves, and causes much injury to the species now in their earlier vegetative stages. Specimens of these grubs are included in my collections—*vide* phial No. 41.

87. The fruit-bearing species above noted, with others of the vegetable class generally cultivated in this district on light sandy soils in proximity to the river, have throughout the past season been much infested with crickets and grasshoppers. The most destructive are those odd-looking creatures exhibited in phial No. 42 of the accompanying collection. They represent the male and female forms of the species. Two full-grown specimens of the latter form are also included with another species of cricket in phial No. 3 of my collection of insects injurious to the poppy plant. They are night-feeding insects, forming deep and extensively ramifying burrows for their retreat and broods. They are extremely wily and difficult to capture. With the exception of moles and shrews they seem to have no natural enemies;

and as both are very scant in this district, they might become a very serious pest to many of our cultivated plants but for their annual decimation in the flooding of their habitats during the rains. The irregular and light rainfall during the monsoon of 1877 favoured them, and they have thus been of late more than usually abundant. This species, other crickets, and a few of the grasshopper tribe, which naturally affect light sandy soils, have thus very seriously injured the crops of the cucurbit family which are more especially cultivated in the basins of the rivers—the Ganges and the Sone.

88. The *roseworts*, or almond family, extensive though it is, is quite unrepresented in our agriculture (with the exception perhaps of the rose-fields of the Ghazeepore district, famous for their attar produce, and which indeed are rather under agricultural than horticultural modes), but unrivalled by any other family in the orchard and the flower-garden for variety and richness of fruit, for beauty and fragrance of flower. I refer to it here simply with respect to the peach (now in season), the fruits of which are largely infested by the larvæ of some dipterous or coleopterous insect. It attacks the fruits in the maturing stage, and we find, on cutting a scarcely blemished mature fruit from the tree, that its inner parts are frequently more or less reduced to a brown rotten pulp, swarming with a small white maggot, specimens of which are forwarded in phial No. 42 of the accompanying collection. A native lessee of several orchards in this district informs me that the peach and aroo-bokhara fruits have never within his experience been so much injured by insects, and that he has thus been obliged to collect them before they were mature, and ripen them artificially, finding that those allowed to mature naturally or on the tree nearly all were more or less injured by maggots. The apricot, an earlier fruit (April), was also very similarly affected and injured by maggots.

89. From roseworts, we have next in natural sequence the legume family, of which the late Dr. Lindley remarks that it "is not only the most extensive but also one of the most important to man, whether we consider the beauty of the numerous species, which are among the gayest coloured and most graceful plants of every region, or their applicability to a thousand useful purposes." The agricultural rubbee plants of this family perhaps more than any other have been injured by insects; for example, the *musoors*, *muturs*, and *urhur*, which with the cereals form the mainstay of agriculture in this district. The injury these crops have sustained by insects has been most serious. From the period of germination until that of maturation they have been almost unremittingly infested with one or another form of insect. First, in the case of the young plants, in December and January a considerable proportion of the crop in this district was destroyed by surface caterpillars very similar, if not identical, with those which attacked the poppy-plant in its earlier stages. The musoors, chuna, muturs, and the common bean were the forms more especially infested with these caterpillars. In this neighbourhood these crops suffered most seriously, large areas of healthy young crops being stripped in a few days, and presenting all the appearance of having been subject to a host of locusts; the destruction indeed could not have been more complete.

90. Again, in February and March other members of the pea family, as the green gram, moot, &c. (*Phaseolus*), the burbuti (*Dolichos*), the various shims (*Lablab* and *Canavalia*), and the urhur (*Cajanus*), which had hitherto been comparatively exempt from insects, were all more or less seriously infested. In the case of the *gram* and *shims*, the leaves were in the first instance attacked by two species of caterpillars, which, as having extended their depredations to the poppy, have been described in treating of that plant. Specimens are exhibited in the accompanying collection—*vide* Nos. 11 and 12. These plants had other enemies in two small beetles, one of which was also common to several of the cucumber family (*vide* No. 35 of my collection), while the other was almost peculiar to the *shims*, both feeding exclusively on the flower and its parts. This species (the latter) was very common, the flower-stalks and the flowers in many cases swarming with them, and so continuing until they had reduced all to bare stalks. This beetle is quite new to me. Specimens with flower-stalks injured by them are shown under No. 44 of my collection.

91. The urhur (*Cajanus indicus*), one of the most valuable and generally cultivated of the Indian legumes, has perhaps more than any other agricultural plant been infested and injured by insects, and this only when it had nearly attained maturation. Throughout the vegetative and flower stages it was unmolested by insects, but the legume was attacked at an early stage by at least three species of caterpillars in this district. One, the most prevalent and destructive, and as having attacked the poppy this season, has been already noticed: the specimens (caterpillar and pupæ forms only) are under No. 12 of my collection. The second species is *mamestra papaverorum*, No. 7 of my specimens, now the hereditary foe of the maturing poppy plant. The third is new to me, and unfortunately the few specimens I had rearing were carried off by a myna, in a rather inadvertent exposure, when their tray was being cleaned. As this occurred late in the season, I failed to get other specimens, and thus I know nothing of the perfect insect. A single specimen of the caterpillar form will be found under No. 45 of my collection, together with an injured legume. Again, specimens No. 46 consist of legumes more or less completely shelled by this and the preceding species, as illustrating the nature of the injury to the crop. This has been most serious, and I hear that in this neighbourhood, in a very large proportion of the legumes, all the seeds had been either wholly devoured or rendered worthless.

92. The *Flax family* is represented by a single member only in Indian agriculture; this is the *tisi* or *alsi* of the Hindustanis (*Linum usitatissimum*). It is very generally cultivated in this country for its oil-yielding seeds, rarely, as in Europe, for its fibre. The late season's crop in this neighbourhood has been nearly all destroyed by caterpillars. This was in January, and mainly by a single species, No. 11 of my collection. It first attacked the leaves, then the young shoots, only quitting it when all was reduced to a bare and dry stalk. In the moist season of 1876-77 the tisi was very much infested and injured by a yellow rust (*Lecythea sp.*) which formed a dense and thick layer over the surface of the leaves. This season I observed that plants which escaped the caterpillars were scarcely at all affected by rust, heat and drought having probably checked its development. Another of our common oil-yielding plants, though of a very different family, deserves a passing notice. This is the *til* or *teel* plant (*Sesamum indicum*), which, as in the case of the common brake-fern (*Pteris aquilina*), as observed by Mr. Francis Darwin and Fritz Muller—*vide* "Nature," *vol.* xxvi, *p.* 100—is afforded a protection from the attacks of injurious insects by the presence of *glands* which as yielding a sweet excretion, are eagerly haunted by a common ant. This ant is a welcome guest, as there can be no doubt that it is a safeguard to the plant from caterpillar and other, insect foes. Indeed, I am almost certain that but for the presence of this ant the *til* crop would scarcely have fared better than the *tisi*, as the caterpillar which destroyed it fed greedily on the *til* plant leaves in the breeding tray. I also found, by placing a few specimens on the growing plant, that immediately on their discovery the ants at once attacked and destroyed them. Thus do these glandular excretions advantage the plant in attracting and supporting a host of ants which protect it from invasion by caterpillars and other unwelcome insect guests.

93. The next and last family which I have to notice is the *Crucifers*, or cabbage order, various members of which have important positions in the garden and the field. They have generally antiscorbutic qualities, frequently pungent, occasionally acrid, juices; and, as containing in the foliage and the seeds various nitrosulphur compounds, emit a very offensive smell when bruised. Such are the general qualities of the plants of this order under nature. Cultivation, however, has greatly modified not only these qualities but the general habit, and rendered them much more liable to the attacks of insects than they are normally under nature. For example, such greatly altered forms as the cabbage and the cauliflower, or the turnip, the raddish, &c., are much more subject to insect infest than are their wild allies. During the late season these plants have suffered much in our garden from insects. Early in the season the young plants had *wireworm* at the roots; these were followed up in many instances by *white-ants*, which completed the plant's destruction. Later caterpillars were frequent, feeding on the younger parts, penetrating to the core of the cabbage, and rendering it unfit for table use.

94. Again, as to the field products of the family, we find these generally more or less affected by other forms of insects. First, the shwet sursha (*Eruca sativa*), which has extremely acrid foliage, escaped caterpillars and other insects in its vegetative stage. The flowers, however, were attacked by a small beetle (No. 47 of my collection), and an aphideous insect of which specimens will be found under No. 48. Both more or less abounded on the flowers and greatly injured the crop, as depending wholly on seed produce for oil extraction. The *field mustards*, comprising the rai, ulta rai, sursun, and shwetrie, were very generally attacked and injured by several species of insects. This, however, was almost confined to the flowering stage, the flowers and the partially matured seeds being the parts most affected. First, in January, with the appearance of the flower-buds these and the younger leaves were very generally attacked by a species of *haltica*, very similar to, if indeed really distinct from, *Haltica nemorum*, the well-known turnip flea-beetle of Europe. I collected many specimens of this insect, but they have been mislaid or lost; and I regret that I can include but a single specimen in my collection, which had been accidentally included in another phial with other mustard flower-feeding beetles. The *Haltica sp.* is No. 49 of the collection. Far more common and destructive to the flowers, however, was the small red beetle (No. 35 of the collection), and already noticed as attacking the flowers of the cucumber family. Another small and pretty beetle allied to the lady-birds (*Coccinella*), with two species of bugs, was also more or less common on the younger leaves and the flower-shoots. Specimens of these are submitted—*vide* Nos. 50, 51, and 52 of my collection. These three species of small beetles and the two bugs appear to have done considerable local injury to the mustard crop; but, its worst enemy has been one of the caterpillars which I have noticed as affecting the poppy various legumes, and linseed. The specimens of this caterpillar are No. 11 of the accompanying collection. They attacked the younger leaves and seed-vessels of all our field mustards, and appear to have done much injury to the crop generally, as largely directing their depredations to the immature seed, the full-grown but partially matured capsules being selected and penetrated by the caterpillar to reach the seeds. These are soft, juicy and easily masticated, so that a single caterpillar will soon pass through a seed-vessel and consume or destroy its whole contents. I am told that the *mustards* forming a *mixed crop with pulses* suffered very much more seriously from caterpillars than those *mixed with barley and wheat*. Indeed, the latter appear to have been almost exempt not only from the caterpillar but also the several small beetles above noticed as infesting the flower-shoots and flowers. We have in

these results, then, a practical illustration of the advantages likely to accrue from a *systematic rotation of cereals* with *pulses, mustard, &c.*, as previously suggested.*

95. In conclusion, and with reference to this report and that previously submitted on the poppy blights of the late crop, I beg that I may be favoured with copies or abstracts of any report by district officers on the subjects of these papers; that is, on the nature and origin of the late poppy blights, the prevalence of insects, and particularly the cause of the greater liability of the poppy to their attacks. From your circular No. 13 of the 13th ultimo I observe that the Member in charge is in communication with the Director of the Indian Museum on the subject of insects injurious to crops; and as I have myself submitted a fairly complete series of those found in this neighbourhood, I beg that a copy of Dr. Anderson's identification of these, with any notes or general report that he may submit, be also forwarded for my information.

Corresponding numbers on phials.

SPECIMENS OF INSECTS INJURIOUS TO THE POPPY AND OTHER CROPS, COLLECTED IN THE GOVENMENT GARDENS AT DEEGAH, MEETAPORE, AND VICINAGE—DINAPORE AND BANKIPORE.

1.—*Insects which attack the young poppy plant in November and December.*

1. *Acheta campestris ?* male and female forms in various stages.
2. *Acheta domestica*; ditto ditto ditto.
3. *Acheta sp.*; common in fields. The two large pale-coloured female forms included in this phial are those of a *fourth* species (found in sandy soils by the river bank), of which I have no males.
4. *Gryllus sp. !* the *ghudya* of the Hindustanees.
5. *Gryllus sp.*, the *phunga* of the Hindustanees.
6. *Gryllotalpa vulgaris*, the *goorgooriah* of the Hindustanees.

2.—*Insects which attack the maturing poppy, February and March.*

7. *Mamestra papaverorum*; young and full-grown larvæ, with portions of poppy stems bored by them.
7*a*. *Mamestra papaverorum*; clusters of ova, mature larvæ, and pupæ.
7*b*. *Mamestra papaverorum*; the perfect insect.
7*c*. *Mamestra papaverorum*; larvæ, pupæ, and insect forms naturally entrapped and killed in poppy capsules, on a small plot of land in the Deegah Gardens.
8. *Noctua sp.*; mature larvæ, pupæ, and perfect insect.
9. *Bombyx sp.*; the *buro-bhooa* of the Hindustanees: full-grown larvæ.
9*a*. The same; cocoons and pupæ cases.
9*b*. The same; the perfect insect.
10. The "*bhooa*" of the Hindustanees; the caterpillar form only.
11. *Bombyx sp.*; the *kala-jhangha* of the assamees: the caterpillar immediately after hatchment, with small portions of leaves injured by them.
11*a*. *The same* caterpillar, six days from its emergence from the egg; with pupa and pupæ cases.
11*b*. *The same*; full-grown caterpillars.
11*c*. *The same*; the perfect insect form.
12. *Noctua sp.*; caterpillar and pupa forms only.
13. *Gryllus sp.*; very young specimens with sections of poppy stem exhibiting the nature of their injuries.
13*a*. *The same*; full-grown insects.

3.—*Insects which attack the poppy-seeds in the granary and store-pots.*

14. *Telranychus papaveræ*; the poppy-seed mite.
15. *Tipula sp.*; the larvæ and pupæ.
16. *Bruchus sp.*; the larva and perfect insect form.
17. *Bruchus sp.*; the perfect insect forms.
18. *Sitona sp.*; the larva and perfect insect forms.
19. *Calandra sp.*; the perfect insect only.
20. Dipterous (!) larvæ, which attack the poppy-seed in the open granary.

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* With reference to Mr. Darwin's views on the protective nature of the milk-sap and other special secretions of plants, I have been much struck to observe that the akund or mudar (*Calotropis gigantea*), a plant replete in all its parts with an acrid, glutinous, and obnoxious milk-sap, is much affected by the *Thyka cucharis* in its caterpillar stage. Unlike any of the insect foes of the poppy, this species attacks the akundo in full vigor, devouring the leaves, the flower-shoots and flower-buds, and is thus a very destructive foe. It appears to be peculiar to the akundo, and strangely enough, even when starved, it would not affect any other of the milk-sap plants which I supplied it with: these were poppy, lettuce, and various figs. It would eat none of them. The akundo has another enemy in a large snout-beetle of a grayish-brown colour, which feeds exclusively on the leaves. I have been unable to get specimens of this insect this season, though it was common enough on the plant at this time last year. Of the *thyka*, which is specially interesting, I send specimens of the larvæ, pupæ and perfect form: these are in phial No. 53 of my collection.

I have thought it worth while to forward herewith specimens of a *locust* which passed over this place on the 1st of July last. They came in a northerly direction across the river, and apparently had had a long journey, as many of them fell into it. The air swarmed with them to a height of from four hundred to five hundred feet. Many of them alighted on the trees and fields, and did considerable injury: the maize crop, in their line of flight, I am told, was nearly all destroyed. After crossing the river at Deegah, they took a south-easterly flight, and it was probably the host noticed in the daily papers as having passed over Luckhiserai on the 5th of July. The specimens are under No. 54 of my collection.

4.—*Insects affecting poppy in the Benares Agency.*

21. Larvæ and pupæ of poppy insects, from Faizabad Sub-Agency.
22. Ditto and perfect forms of poppy insects from Gorakhpore Sub-Agency.
23. Capsules of poppy destroyed by *Bombyx sp.*, the *kala-jhanghi* of the natives.
24. Pupæ and pupa-cases, with portions of wing of perfect insect from poppy in the Cawnpore Sub-division.
25. Cawnpore Sub-division: *Sitona sp.*; perfect and pupa forms, and a small dipterous insect with pupa-form.
26. Capsules seriously injured by caterpillars from Lucknow Sub-Agency.
27. Bareilly Sub-division: pupæ of *mamestra papaverorum.*
28. Capsules of wild and cultivated poppy, as illustrating their porous and nonporous structure.

5.—*Insects affecting the rubbee or cold season crops generally in the field and the garden.*

29. Larvæ, pupæ, and perfect forms of insects affecting brinjal fruits.
30. Ditto of an insect affecting the flower-heads of the koosoom plant.
31. Ditto, pupæ, and perfect form of insects which injure koosoom flower-heads.
32. Specimens of an aphis abounding on, and causing much injury to, the late koosoom crops.
33. Specimen of an artichoke tortoise beetle (*cassida sp.*).
34. Ditto of a common beetle which infests young plants of the cucumber family.
35. Ditto of another species affecting the above plants in the flowering stage.
36. Ditto of four different *bugs* which, so far as I can make out, feed on the flower juices of the cucumber family.
37. Specimens of beetles, four species, which feed on the leaves and flowers of certain species of the above family.
38. Specimens of lady-bird; grubs, with leaf-shoots of the 'kudoo' plant injured by them.
39. Specimens of pupæ, and perfect forms of the same, with leaves skeletonised by the latter.
40. Specimens of an aphis very common this season on various species of the cultivated *cucurbits.*
41. Grubs of a beetle very common on the cultivated varieties of cucurbits in the month of May.
42. Specimens of a member of the cricket family which has done much damage to *melon* and *cucumber* crops.
43. Specimens of maggots affecting the fruits of the peach and aroo-bokhara.
44. Ditto of a small greyish-green coloured beetle, almost peculiar to the *shims*, and feeding on their flowers.
45. Specimen of a caterpillar which attacks the legumes, and devours the seed of the urhur plants (*Cajanus indicus*).
46. Specimens of urhur legumes, injured by insects.
47. Specimens of a small beetle which feeds on the flowers of *Eruca sativa.*
48. A member of the Aphideæ family, which also attacks the flowers of the above plant.
49. *Haltica sp.*; a flea-beetle which feeds on the young leaves and flower-buds of 'rai,' &c.
50. *Coccinella sp.;* a small beetle which feeds on the flower-shoots and flowers of the common field mustards.
51. Specimens of a bug which affects the flowers-shoots and flowers of the field mustards.
52. Specimens of another species similarly affecting these plants.
53. *Thyka eucharis;* larvæ, pupæ, and perfect form affecting the akund (*Calotrepis gigantea*).
54. *Locusta sp.*: specimens of a host which passed over Deegah on the 1st of July 1877.

JOHN SCOTT.

DEEGAH,
The 28th May 1878.

C. E. G. and others.—Reg. No. 1938—10—24.6.78.

REPORT

ON THE

EXPERIMENTAL CULTURE OF THE OPIUM POPPY

FOR THE SEASON 1877-78.

BY

JOHN SCOTT, Esq.,

Curator, Royal Botanical Garden, Calcutta; late on special duty, Opium Department.

Calcutta:

PRINTED AT THE BENGAL SECRETARIAT PRESS.

1878.